

# Bonn zoological Bulletin

Volume 67  
Issue 1  
2018

formerly: Bonner zoologische Beiträge



An open access journal of organismal zoology, published by  
Zoologisches Forschungsmuseum Alexander Koenig, Bonn

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## In memoriam Dr. Hans Ulrich (1934–2017)

Wolfgang Böhme & Rainer Hutterer

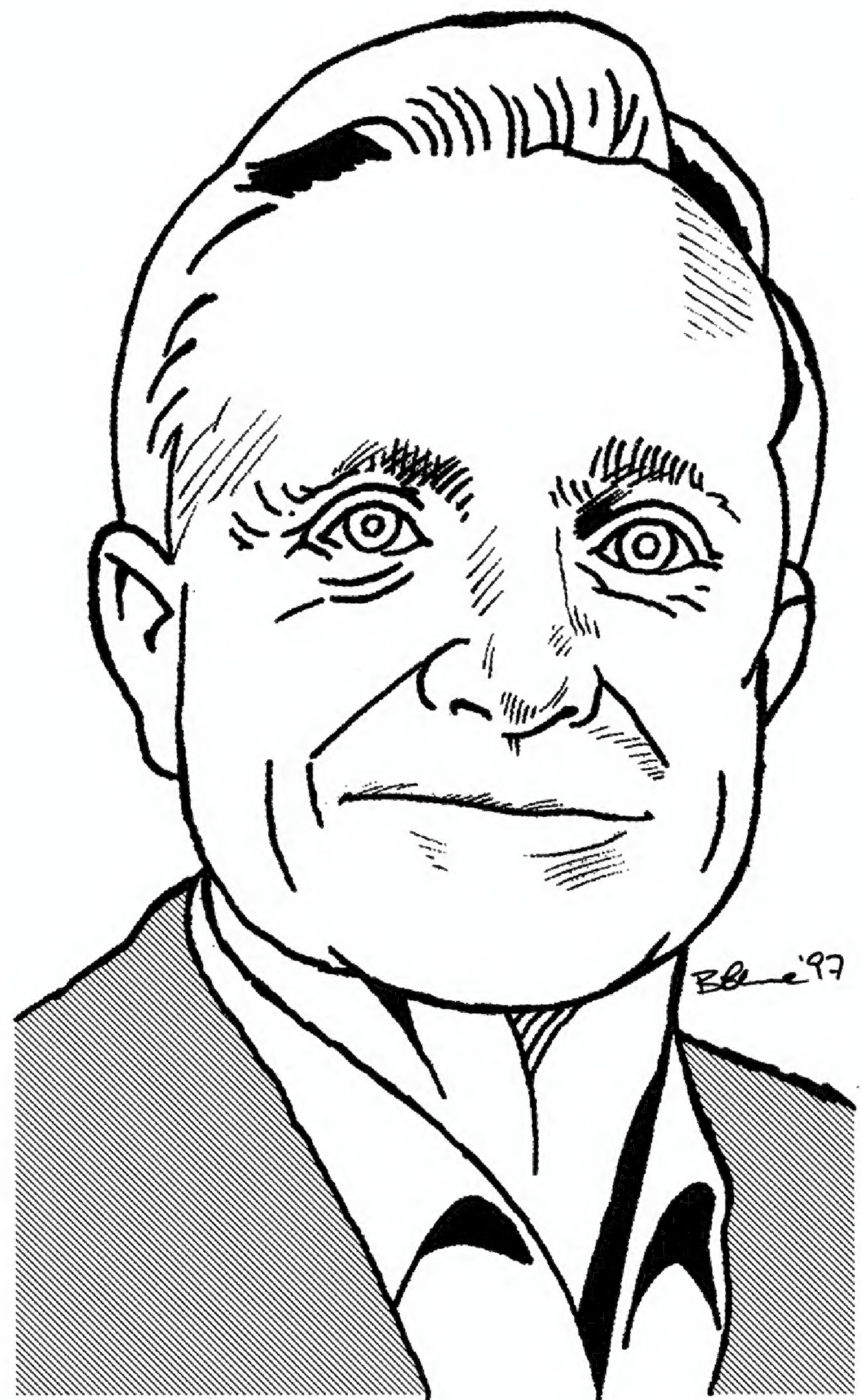
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On May 24, 2017, the long-term curator of the Diptera section of Museum Koenig, Dr. Hans Ulrich, passed away at the age of 83 years. With this obituary, we want to commemorate and celebrate his life and his scientific activities.

Hans Ulrich was born as the third child of the former Reichsbank inspector and later Bankrat (retired) Ferdinand Ernst Hans Hugo Ulrich and his wife Matilde Margarethe Marie Ulrich, born Löllke, on July 22, 1934 at Stendal, Saxony-Anhalt. In 1938 the family moved to Ludwigsburg in Baden-Württemberg. In December 1944, an aerial bomb attack destroyed most of the household. They moved to relatives at Nordhausen (Harz) where in two new aerial attacks in April 1945 the family lost again all they had. Shortly after the end of World War II and before the occupation of Thuringia by the Soviet army they returned to Württemberg and found a first quarter at Mundelsheim on the Neckar, then in Ludwigsburg and finally in Stuttgart.

Hans Ulrich entered basic school in spring 1940 and moved to high school in summer 1944. He finished his maturation at the Friedrich Schiller High School in Ludwigsburg. He started his university studies in biology, chemistry and geology at the Technical University Stuttgart and at the University of Tübingen in summer semester 1953 and finished in spring 1960 with an examination (state examen) for school teachers. On March 12, 1962 he received his doctoral degree with a histological dissertation on hippoboscid flies (Diptera: Hippoboscidae), at the Faculty of Natural Sciences of the Technical University of Stuttgart, under the tutorship of Prof. Dr. Otto Pflugfelder (1904–1994).

From May 1957 to April 1962, with one year interruption, Hans Ulrich served the Zoological Institute of the Technical University Stuttgart and the nearby Agricultural University Hohenheim. Subsequently, from May 1962 to June 1963, he became part of a team at the Landesanstalt für Pflanzenschutz (State institute for plant protection) within a focus program of the Deutsche Forschungsgemeinschaft (German Science Foundation, DFG) called “Integrative plant protection”. Next station of his career was a temporary employment as a scientific assistant at the Staatliches Museum für Naturkunde in Stuttgart, Department of Phylogenetic Research, from July 1963 to December 1965. These two and a half years



**Fig. 1.** Dr. Hans Ulrich (Sketch drawn by Peter Böhme).

were particularly important for him, since he proved to be the only assistant of the world-famous phylogeneticist Prof. Willi Hennig (1913–1976), and he became strongly influenced by Hennigian thinking for all his further scientific work.

A further station on his way was a temporary employment, within a DFG sponsored project at the Institut für Biologische Schädlingsbekämpfung (Institute for biological combat against noxious organisms) in Darmstadt, combatting the noxious tortricid moth *Cydia pomonella* Linnaeus, 1758 (Lepidoptera: Tortricidae). And only



thereafter, being employed again by the DFG at the Zoologische Staatssammlung München (Zoological State Collection Munich), he finally found his long-term special field of research, viz. the taxonomy and anatomy of two dipteran families: Dolichopodidae and Empididae.

In December 1971, he entered the Zoologisches Forschungsmuseum Alexander Koenig as a curator of dipterology and took responsibility for a collection which had been brought to international reputation by his predecessor Dr. Bernhard Mannheims (1909–1971), mainly in respect to blepharicerids, tipulids and limoniids. Internationally important was also the collection of phorid flies. Until the employment of a curator of hymenopterology in 1986, Hans Ulrich took also care of the Hymenoptera collection. In 1974 he became a preliminary civil servant which was extended to permanency in 1977.

Since 1974 he had an own assistant in his section, Mrs. Christa Große-Streuer, who helped him in all respects including his activity as editor of two ZFMK journals “Bonner zoologische Beiträge” (Festschrift H. E. Wolters 1975 and volumes 31–35, 1980–1984) and “Bonner zoologische Monographien” (nos 12–16, 1979–1982).

Hans Ulrich worked as a curator until 1999, and then continued as a volunteer until about 2012, his visits became rare. He spent quite some money on fossil Diptera, most of which he donated to the museum’s collections. He also donated his books, and finally his house. He was a really generous curator.

### Taxon names coined by H. Ulrich and colleagues

*Amphithalassius* Ulrich, 1991  
*Amphithalassius latus* Ulrich, 1991  
*Amphithalassius piricornis* Ulrich, 1991  
*Microphorella similis* Brooks & Ulrich, 2012  
*Plesiothalassius flavus* Ulrich, 1991  
*Plesiothalassius natalensis* Ulrich, 1991  
 (all Diptera: Dolichopodidae)

### Taxa named after H. Ulrich

*Ulrichophora* Brown, 2007 (Diptera: Phoridae)  
*Metopina ulrichi* Disney, 1979 (Diptera: Phoridae)  
*Microphorella ulrichi* Gatt, 2003  
 (Diptera: Dolichopodidae)

### Publications List

Ulrich H (1963) Vergleichend histologische und zyklische Untersuchungen an den weiblichen Geschlechtsorganen und den innersekretorischen Drüsen adulter Hippobosciden (Diptera Pupipara). Deutsche entomologische Zeitschrift (Neue Folge) 10: 28–71

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Ulrich H (1966) Zum Aufbau der Ovarien von *Glossina morsitans* (Diptera). Deutsche entomologische Zeitschrift (neue Folge) 13: 379–382

Ulrich H (1968) Versuche über die Empfindlichkeit von *Trichogramma* (Hymenoptera, Chalcidoidea) gegenüber Fungiziden. Anzeiger für Schädlingskunde 40: 101–106

Ulrich H (1968) Ein verbesserter Käfig für die Massenaufzucht des Eiparasiten *Trichogramma* (Hymenoptera, Chalcidoidea). Entomophaga 13: 233–236

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Ulrich H (1972) Der Gattungsname *Anoplomerus* Rondani (Diptera, Dolichopodidae). Opuscula zoologica 111: 1–4

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Ulrich H (1975) Das Hypopygium von *Chelifera precabunda* Collin (Diptera, Empididae). Bonner zoologische Beiträge 26: 264–279

Ulrich H (1978) Abwandlungen im Bau des Dolichopodiden-Hypopygiums (Diptera) – I: *Medetera truncorum* Meigen. Bonner zoologische Beiträge 28: 412–420

Ulrich H (1980) Subfamilies of Dolichopodidae (Diptera). Abstracts of the 16<sup>th</sup> International Congress of Entomology: 24

Ulrich H (1980) Zur systematischen Gliederung der Dolichopodiden (Diptera). Bonner zoologische Beiträge 31: 385–402

Ulrich H (1984) Skelett und Muskulatur des Thorax von *Microphor holosericeus* (Meigen) (Diptera, Empidoidea). Bonner zoologische Beiträge 35: 351–398

Ulrich H (1988) Das Hypopygium von *Microphor holosericeus* (Meigen) (Diptera, Empidoidea). Bonner zoologische Beiträge 39: 179–219

Ulrich H (1991) Two new genera of parathalassine-like flies from South Africa (Diptera, Empidoidea). Bonner zoologische Beiträge 42: 187–216

Ulrich H, Schmelz R M (1998) Enchytraeidae (Oligochaeta) as prey of Dolichopodidae, recent and in Baltic amber. Abstract 4<sup>th</sup> international Congress on Diptera (Oxford): 231

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Brooks S E, Ulrich H (2012) *Microphorella similis* sp. nov. from Switzerland, a close relative of the type species, *Micro-*



*phorella praecox* (Loew) (Diptera: Dolichopodidae: Parathalassiinae). Zootaxa 3489: 45–57

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# Loktak Lake, Manipur, revisited: A Ramsar site as the rotifer (Rotifera: Eurotatoria) biodiversity hot-spot of the Indian sub-region

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**Abstract.** The plankton and semi-plankton samples collected at Loktak Lake in Manipur state of northeast India (NEI), between February 2015 and January 2017, revealed 180 rotifer species belonging to 42 genera and 22 families. Our report raises the total richness of the phylum known from this Ramsar site to 189 species and thus assigns this floodplain wetland the status of the most species-rich rotifer hot-spot of the Indian sub-region. Two species are new to the Oriental region and 25 are new records from Manipur. The rotifer fauna is characterized by a number of species of global (~18% of species) and regional biogeographic (~15% of species) interest, high richness and common occurrence of ‘tropic centered’ *Lecane*, relative paucity and scarceness of *Brachionus*, *Filinia*, *Hexarthra* and *Conochilus* species, and littoral-periphytic assemblages with a number of small-sized species. The present study is interesting for the rotifer ecosystem diversity update of this well-sampled floodplain wetland of the Indian sub-region. We estimate 270+ Rotifera species from this lake system pending specific analysis of periphytic, colonial, and benthic taxa as well as of likely cryptic diversity of certain species complexes.

**Key words.** Biogeography, ecosystem diversity, floodplain wetland, heterogeneity.

## INTRODUCTION

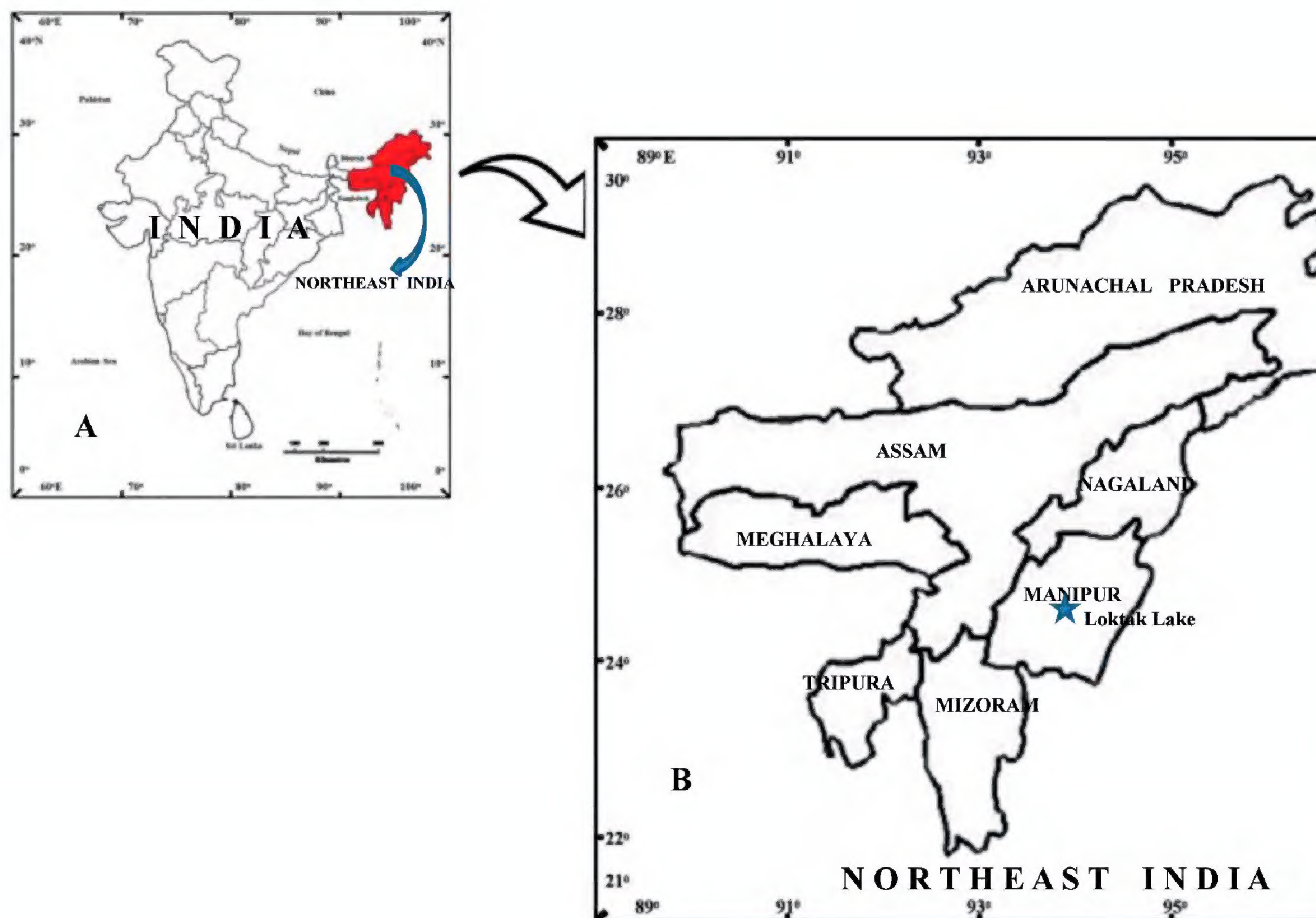
Rotifera have been documented and described from different parts of India for more than a century but there is still paucity of information on their ecosystem diversity in different aquatic biotopes because of limited studies, inadequate sampling, incomplete inventories and lack of taxonomic expertise (Sharma & Sharma 2017). Nevertheless, our investigations over the last two decades have highlighted the global importance of the floodplain lakes (locally termed ‘beels’ or ‘pats’) of northeast India (NEI) (Sharma & Sharma 2014a, 2014b, 2017) regarding Rotifera biodiversity and biogeography. Deepor beel, a Ramsar site located in this region, has been reported to be one of the most rotifer speciose individual ecosystems of India (Sharma & Sharma 2015). Sharma et al. (2016) extended the investigations to Loktak Lake – another Ramsar site – and provided a notable update on the rotifer fauna reported earlier by Sharma (2009). The present intensive sampling culminated in more biodiverse assemblage characterizing this floodplain wetland of NEI as a rotifer hot-spot of the Indian sub-region. An inventory of the rotifer species recorded till date from Loktak Lake is presented. Remarks are made on salient features of the composition and species richness of Rotifera, and on new records and taxa of biogeographic importance. Various interesting species reported in this study are illustrated.

## MATERIAL & METHODS

Loktak Lake (93° 46′ – 93° 55′ E, 24° 25′ – 24° 42′ N; area: 286 km<sup>2</sup>; max. depth: 4.58 m, mean depth: 2.07 m), Bishnupur/Imphal districts of Manipur (NEI), is an interesting floodplain lake system (Figs 1 A–C) characterized by its floating mats of vegetation called “Phumdi” which are inhabited by endangered brow-antlered deer (*Rucervus eldi eldi*). This Ramsar site is reported to have a diverse assemblage (233 species) of aquatic macrophytes (Tunginba Singh, 2013).

The qualitative plankton and semi-plankton samples were collected between February 2015 and January 2017 at three sampling sites: Loktak A (93°45′56.3″ E; 24°32′13.5″ N; alt. 726 m asl), Loktak B (93°47′58.1″ E; 24°30′39.1″ N; alt. 714 m asl) and Loktak Barrage (93°45′43.5″ E; 24°32′46.9″ N; alt. 718 m asl). In addition, others from different parts (pats) of Loktak Lake basin are analyzed. The samples were collected by towing a nylobolt plankton net (#50 µm mesh size) and preserved in 5% formalin. All samples were screened with a Wild stereoscopic binocular microscope; individual rotifers were isolated and mounted in Polyvinyl alcohol-lactophenol, and were observed with a Leica (DM 1000) stereoscopic phase contrast microscope fitted with an image analyzer. The rotifer taxa were identified using Koste (1978), Segers (1995), Sharma (1978a, 1978b, 1983, 1998), Sharma & Sharma (1987, 1997, 1999, 2000, 2008, 2013), and Jersabek and Leitner (2013). The voucher collections are in the holdings of the Department of Zoology, North-Eastern Hill University, Shillong.





**Fig. 1A–C.** **A.** Map of India showing northeast India; **B.** Map of northeast India indicating Manipur state and location of Loktak Lake; **C.** Loktak Lake – a Ramsar site showing typical ‘Phumdi’



## RESULTS

A total of 180 species representing 42 genera and 22 families were identified in our collections from Loktak Lake. Our study raises the total number of rotifers known from this Ramsar site to 189 species. The following is a detailed systematic list of the recorded taxa.

### Systematic list of Rotifera recorded from Loktak Lake, Manipur

**Phylum:** Rotifera  
**Class:** Eurotatoria  
**Subclass:** Monogononta  
**Order:** Ploima

#### Family: Brachionidae

1. *Amuraeopsis fissa* (Gosse, 1851)
2. *Brachionus angularis* Gosse, 1851
3. *B. bidentatus* Anderson, 1889
4. *B. calyciflorus* Pallas, 1766
5. *B. caudatus* Barrois & Daday, 1894
6. *B. diversicornis* (Daday, 1883)\*\*
7. *B. durgae* Dhanapathi, 1974
8. *B. falcatus* Zacharias, 1898
9. *B. forficula* Wierzejski, 1891\*\*
10. *B. kostei* Shiel, 1983
11. *B. mirabilis* Daday, 1897
12. *B. quadridentatus* (Hermann, 1783) s. lat
13. *Keratella cochlearis* Gosse, 1851
14. *K. edmondsoni* Ahlstrom, 1943\*\*
15. *K. lenzi* Hauer, 1953
16. *K. tecta* (Gosse, 1851)
17. *K. tropica* (Apstein, 1907)
18. *Platyias leloupi* (Gillard, 1967)
19. *P. quadricornis* (Ehrenberg, 1832)
20. *Platiumus patulus* (O.F. Müller, 1786)

#### Family: Epiphanidae

21. *Epiphanes brachionus* (Ehrenberg, 1837)

#### Family: Euchlanidae

22. *Beauchampiella eudactylota* (Gosse, 1886)
23. *Dipleuchlanis propatula* (Gosse, 1886)
24. *Euchlanis dilatata* Ehrenberg, 1832
25. *E. incisa* Carlin, 1939
26. *E. meneta* Myers, 1930
27. *E. semicarinata* Segers, 1993#
28. *E. triquetra* Ehrenberg, 1838
29. *Tripleuchlanis plicata* (Levander, 1894)

#### Family: Mytilinidae

30. *Lophocharis salpina* (Ehrenberg, 1834)
31. *Mytilina acanthophora* Hauer, 1938
32. *M. brevispina* (Ehrenberg, 1830)\*\*

33. *M. bisulcata* (Lucks, 1912)
34. *M. lobata* Pourriot, 1996
35. *M. michelangellii* Reid & Turner, 1988
36. *M. ventralis* (Ehrenberg, 1832)

#### Family: Trichotriidae

37. *Macrochaetus danneelae* Koste & Shiel, 1983
38. *M. longipes* (Myers, 1934)
39. *M. sericus* (Thorpe, 1893)
40. *Trichotria tetractis* (Ehrenberg, 1830)
41. *Wolga spinifera* (Western, 1894)

#### Family: Lepadellidae

42. *Colurella adriatica* (Ehrenberg, 1837)
43. *C. obtusa* (Gosse, 1886)
44. *C. sulcata* (Stenroos, 1898)
45. *C. uncinata* (O.F. Müller, 1773)
46. *Lepadella acuminata* (Ehrenberg, 1834)
47. *L. apsicora* Myers, 1934
48. *L. apsida* Harring, 1916
49. *L. benjamini* Harring, 1916
50. *L. bicornis* Vasisht & Battish, 1971
51. *L. biloba* Hauer, 1958\*\*
52. *L. cristata* (Rousselet, 1893)\*\*
53. *L. costatoides* Segers, 1992
54. *L. dactyliseta* (Stenroos, 1898)
55. *L. desmeti* Segers & Chittapun, 2001
56. *L. discoidea* Segers, 1993
57. *L. ehrenbergi* (Perty, 1850)
58. *L. eurysterna* Myers, 1942
59. *L. heterostyla* (Murray, 1913)
60. *L. lindau* Koste, 1981
61. *L. neglecta* Segers & Dumont, 1995\*
62. *L. minuta* (Weber & Montet, 1918)
63. *L. ovalis* (O.F. Müller, 1786)
64. *L. patella* (O.F. Müller, 1773) s. lat
65. *L. quadricarinata* (Stenroos, 1898)
66. *L. quinquecostata* (Lucks, 1912)
67. *L. rhomboides* (Gosse, 1886)
68. *L. triba* Myers, 1934
69. *L. triptera* Ehrenberg, 1830
70. *L. vandenbrandei* Gillard, 1952
71. *Squatinella mutica* (Ehrenberg, 1832)

#### Family: Lecanidae

72. *Lecane acanthinula* (Hauer, 1938)#
73. *L. aculeata* (Jakubski, 1912)
74. *L. aeganea* Harring, 1914
75. *L. arcua* Harring, 1914
76. *L. aspasia* Myers, 1917
77. *L. batillifer* (Murray, 1913)\*\*
78. *L. blachei* Berzins, 1973
79. *L. bifastigata* Hauer, 1938\*\*
80. *L. bifurca* (Bryce, 1892)
81. *L. bulla* (Gosse, 1851) s. lat
- L. bulla diabolica* (Hauer, 1936)



82. *L. closterocerca* (Schmarda, 1898)
83. *L. crepida* Harring, 1914
84. *L. curvicornis* (Murray, 1913) s. lat
85. *L. decipiens* (Murray, 1913)
86. *L. dorysimilis* Trinh Dang, Segers & Sanoamuang, 2015\*\*
87. *L. doryssa* Harring, 1914
88. *L. elegans* Harring, 1914
89. *L. elongata* Harring & Myers, 1926\*\*
90. *L. flexilis* (Gosse, 1886)
91. *L. furcata* (Murray, 1913)
92. *L. hamata* (Stokes, 1896) s. lat
93. *L. haliclysta* Harring & Myers, 1926
94. *L. hastata* (Murray, 1913)\*\*
95. *L. hornemanni* (Ehrenberg, 1834)
96. *L. inermis* (Bryce, 1892)
97. *L. inopinata* Harring & Myers, 1926
98. *L. lateralis* Sharma, 1978
99. *L. latissima* Yamamoto, 195\*\*
100. *L. leontina* (Turner, 1892)
101. *L. ludwigii* (Eckstein, 1883)
102. *L. luna* (O.F. Müller, 1776) s. lat
103. *L. lunaris* (Ehrenberg, 1832)
104. *L. marchantaria* Koste & Robertson, 1983\*
105. *L. monostyla* (Daday, 1897)
106. *L. nitida* (Murray, 1913)
107. *L. niwati* Segers, Kothetip & Sanoamuang, 2004
108. *L. obtusa* (Murray, 1913)
109. *L. ohioensis* (Herrick, 1885)
110. *L. papuana* (Murray, 1913)
111. *L. ploenensis* (Voigt, 1902)
112. *L. pusilla* Harring, 1914
113. *L. pyriformis* (Daday, 1905)\*\*
114. *L. quadridentata* (Ehrenberg, 1832)
115. *L. rhenana* Hauer, 1929
116. *L. rhytida* Harring & Myers, 1926
117. *L. ruttneri* Hauer, 1938
118. *L. signifera* (Jennings, 1896)
119. *L. simonneae* Segers, 1993
120. *L. solfatara* (Hauer, 1938)#
121. *L. stenroosi* (Meissner, 1908)
122. *L. superaculeata* Sanoamuang & Segers, 1997\*\*
123. *L. syngenes* (Hauer, 1938)\*\*
124. *L. tenuiseta* Harring, 1914
125. *L. thienemanni* (Hauer, 1938)
126. *L. undulata* Hauer, 1938
127. *L. unguitata* (Fadeev, 1925)
128. *L. ungulata* (Gosse, 1887)

**Family: Notommatidae**

129. *Cephalodella forficula* (Ehrenberg, 1832)
130. *C. gibba* (Ehrenberg, 1832)
131. *C. mucronata* Harring & Myers, 1921
132. *C. trigona* (Rousselet, 1895)\*\*
133. *Monommata longiseta* (O.F. Müller, 1786)
134. *M. maculata* (Harring & Myers, 1924)

135. *Monommata* sp.#

136. *Notommata spinata* Koste & Shiel, 1991

**Family: Scaridiidae**

137. *Scaridium longicaudum* (O.F. Müller, 1786)

**Family: Gastropodidae**

138. *Ascomorpha ecaudis* Perty, 1850

139. *A. ovalis* (Bergendal, 1892)

**Family: Trichocercidae**

140. *Trichocerca abiloi* Segers & Sarma, 1993#

141. *T. bicristata* (Gosse, 1887)

142. *T. capucina* (Wierzejski & Zacharias, 1893)\*\*

143. *T. cylindrica* (Imhof, 1891)

144. *T. edmondsoni* (Myers, 1936)

145. *T. elongata* (Gosse, 1886)

146. *T. flagellata* Hauer, 1938

147. *T. insignis* (Herrick, 1886)

148. *T. hollaerti* De Smet, 1990

149. *T. longiseta* (Schränk, 1802)

150. *T. maior* Hauer, 1936

151. *T. pusilla* (Jennings, 1903)\*\*

152. *T. rattus* (O.F. Müller, 1786)

153. *T. scipio* (Gosse, 1886)

154. *T. similis* (Wierzejski, 1893)

155. *T. sulcata* (Jennings, 1894)\*\*

156. *T. tenuior* (Gosse, 1886)

157. *T. weberi* (Jennings, 1903)

**Family: Asplanchnidae**

158. *Asplanchna priodonta* Gosse, 1850

**Family: Synchaetidae**

159. *Ploesoma lenticulare* Herrick, 1855

160. *Polyarthra vulgaris* Carlin, 1943

161. *Synchaeta oblonga* Ehrenberg, 1832\*\*

162. *S. pectinata* Ehrenberg, 1832

**Family: Dicranophoridae**

163. *Dicranophoroides caudatus* (Ehrenberg, 1832)

164. *Dicranophorus forcipatus* (O.F. Müller, 1786)

**Order: Gnesiotrocha**

**Family: Flosculariidae**

165. *Floscularia ringens* (Linnaeus, 1758)#

166. *Sinantherina semibullata* (Thorpe, 1893)

167. *S. spinosa* (Thorpe, 1893)

168. *S. socialis* (Linnaeus, 1758)

**Family: Hexarthridae**

169. *Hexarthra mira* (Hudson, 1871)\*\*

**Family: Conochilidae**

170. *Conochilus unicornis* Rousselet, 1892



**Family: Testudinellidae**171. *Testudinella amphora* Hauer, 1938172. *T. brevicaudata* Yamamoto, 1951173. *T. emarginula* (Stenroos, 1898)174. *T. parva parva* (Ternetz, 1892)*T. parva bidentata* (Ternetz, 1892)\*\*175. *T. patina* (Hermann, 1783)176. *T. tridentata* Smirnov, 1931**Family: Trochosphaeridae**177. *Filinia brachiata* (Rousselet, 1916)#178. *F. camasecla* Myers, 1938179. *F. longiseta* (Ehrenberg, 1834)180. *F. opoliensis* (Zacharias, 1898)181. *F. saltator* (Gosse, 1886)182. *Trochosphaera aequatorialis* Semper, 1872**Family: Collothecidae**183. *Collotheca ornata* (Ehrenberg, 1832)\*\***Subclass: Digononta****Order: Bdelloidea****Family: Habrotrochidae**184. *Habrotrocha angusticollis* (Murray, 1905)#**Family: Philodinidae**185. *Dissotrocha aculeata* (Ehrenberg, 1832)\*\*186. *Rotaria macroceros* (Gosse, 1851)187. *R. neptunia* (Ehrenberg, 1832)188. *R. rotatoria* (Pallas, 1766)\*\*189. *R. tardigrada* (Ehrenberg, 1830)#

\* New records from India; \*\* New records from Manipur; # not observed in this study

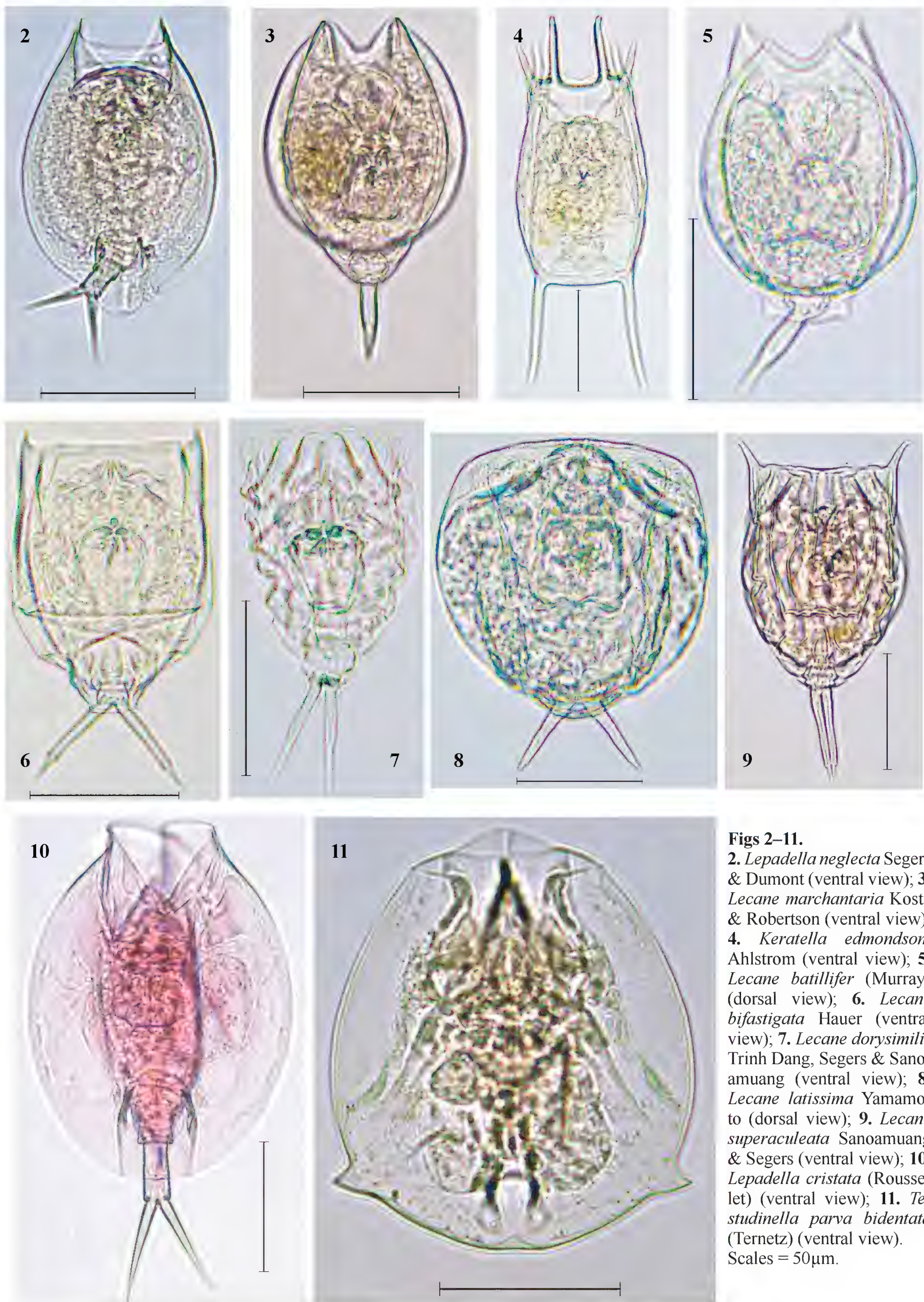
*Lepadella neglecta* (Fig. 2) and *Lecane marchantaria* (Fig. 3) are new records from India. *Brachionus diversicornis*, *B. forficula*, *Cephalodella trigona*, *Collotheca ornata*, *Dissotrocha aculeata*, *Hexarthra mira*, *Keratella edmondsoni* (Fig. 4), *Lecane batillifer* (Fig. 5), *L. bifastigata* (Fig. 6), *L. dorysimilis* (Fig. 7), *L. elongata*, *L. hastata*, *L. latissima* (Fig. 8), *L. pyriformis*, *L. superaculeata* (Fig. 9), *L. syngenes*, *Lepadella biloba*, *L. cristata* (Fig. 10), *Mytilina brevispina*, *R. rotatoria*, *Synchaeta oblonga*, *Trichocerca capucina*, *T. pusilla*, *T. sulcata* and *Testudinella parva bidentata* (Fig. 11) are new records from Manipur state of NEI. Lecanidae (57 species), Lepadellidae (30 species), Brachionidae (20 species), and Trichocercidae (18 species) collectively formed 66.1% (125 species) of the total rotifer species richness now known from Loktak Lake. Euchlanidae and Notommataidae included eight species each, while Testudinellidae and Trochosphaeridae are represented by six species each.

**DISCUSSION**

Our report of 180 species characterizes the biodiverse rotifer assemblages of Loktak Lake, raises the total species richness known from this wetland to 189 species and thus categorizes this Ramsar as the most species rich Rotifera hot-spot of the Indian sub-region and one of the globally most diverse rotifer biotopes. The results affirm the hypothesis of Segers et al. (1993) on (sub) tropical floodplains as the world's richest rotifer habitats and also endorse the speciose nature of the rotifers of the floodplain lakes of NEI (Sharma & Sharma 2014a, 2014b). The total species richness comprises ~42% and ~76% of Rotifera species known till date from India (Sharma & Sharma 2017) and northeast India (BKS, unpublished), respectively. Our inventory exceeds the highest Indian report of 171 rotifer species (Sharma & Sharma 2015) from Deepor beel – a Ramsar site and an important floodplain lake of NEI. This study marks a significant richness update on the taxon from Loktak basin compared to earlier reports of 120 (Sharma 2009) and 152 species (Sharma et al. 2016). The listing of 42 genera and 22 families affirms rich higher level diversity of Eurotatoria as compared with 65 genera and 25 families of the phylum known from India (Sharma & Sharma 2017). The biodiverse Rotifera fauna is hypothesized to result from micro-habitat diversity and environmental heterogeneity of Loktak Lake while high richness in our plankton and semi-plankton collections is hypothesized to result from greater habitat diversification due to the influence of the littoral vegetation (Green 1972; Serafim et al. 2003). We also attribute the reported high richness to the 'rotiferologist effect' (cf. Fontaneto et al. 2012).

The Rotifera species richness of Loktak Lake concurs with the report of "All Taxa Biological Inventories (ATBI)" for the rotifer assemblages of the tropical and subtropical lakes, listing between 123 and 210 species (Dumont & Segers 1996). Total richness is lower than 207, 230 and 252 species reported from the floodplains of Africa (Segers et al. 1993), South America (Serafim Jr. et al. 2003), and Australia (Shiel et al. 1998) while it broadly corresponds with 184 examined species from the Upper Paraná floodplain (Bonecker et al. 1994, 1998, 2005; Lansac-Tôha et al. 1997) of Brazil. On the other hand, Loktak Rotifera is more diverse than the records of 114 species (Jose de Paggi 2001) from the Rio Pilcomayo National Park (a Ramsar site), Argentina, 124 species (Oguta lake) and 136 species (Iyi-Efi lake) from the Niger delta (Segers et al. 1993) of Africa, 130 species from Lake Guarana, Brazil (Bonecker et al. 1994), 106 taxa from Thale-Noi Lake, a Ramsar site in Thailand (Segers & Pholpunthin 1997), 104 species from Laguna Bufeos, Bolivia (Segers et al. 1998), and 151 (Koste 1974) and 148 species from Rio Tapajos and Lago Camaleao (Koste & Robertson 1983) of Brazil, respectively.



**Figs 2–11.**

**2.** *Lepadella neglecta* Segers & Dumont (ventral view); **3.** *Lecane marchantaria* Koste & Robertson (ventral view); **4.** *Keratella edmondsoni* Ahlstrom (ventral view); **5.** *Lecane batillifer* (Murray) (dorsal view); **6.** *Lecane bifastigata* Hauer (ventral view); **7.** *Lecane dorysimilis* Trinh Dang, Segers & Sanoamuang (ventral view); **8.** *Lecane latissima* Yamamoto (dorsal view); **9.** *Lecane superaculeata* Sanoamuang & Segers (ventral view); **10.** *Lepadella cristata* (Rousset) (ventral view); **11.** *Testudinella parva bidentata* (Ternetz) (ventral view). Scales = 50µm.



The two Neotropical species (Segers 2007) *Lepadella neglecta* and *Lecane marchantaria* are new to the Oriental Rotifera. The former was described (Segers & Dumont 1995) from Lobo (Broa) reservoir, Brazil; it was confused in the past (Segers & Dumont loc cit.) with *L. quinquecostata*. This remark deserved caution as *L. neglecta* is characterized by its pyriform lorica, slightly narrowed aperture, dorsum domed with seven low but conspicuous semi-longitudinal ridges, and posterior margin projecting and with a minute median notch and thus differed distinctly in its morphology from the latter. *Lecane marchantaria* is deemed to be confused (Segers 1995) with the *L. hamata* complex; it is differentiated from the latter by nearly coincident and broadly V-shaped head aperture margins. Our collections from Loktak basin add 25 new records to the rotifer fauna of Manipur. Our collections reveal important fractions of species of global (~18% of species; 34 species) and regional biogeographic interest (~15% of species; 27 species). The Australasian *Lecane batillifer*, the Neotropical *Lepadella neglecta* and *L. marchantaria*, the Oriental *Keratella edmondsoni*, *Lecane latissima* and *L. superaculeata*, the Indo-Chinese *Lepadella dorysimilis*, and *Cephalodella trigona* and *Lecane bifastigata* are new to the list of Rotifera from Loktak. *Brachionus kostei*, *Dissotrocha aculeata*, *Euchlanis semicarinata*, *Filinia camascela*, *Notommata spinata*, *Lecane aeganea*, *L. aspasia*, *L. dorysimilis*, *L. latissima*, *L. rhenana*, *L. rhytida*, *L. niwati*, *L. solfatar*, *L. superaculeata*, *L. undulata*, *Lepadella desmeti*, *L. vandenbrandei*, *Monommata maculata*, *Notommata spinata*, *Testudinella amphora*, *T. brevicaudata*, *T. parva bidentata*, *Trichocerca abiloi*, *T. edmondsoni*, *T. hollaerti*, *T. maior* and *T. sulcata* are examples of species of regional distribution interest in the Indian Rotifera with their distribution limited till date to NEI (Sharma & Sharma 2017).

Lecanidae > Lepadellidae > Brachionidae > Trichocercidae collectively form a large fraction (~66% of species) of the rotifer fauna of Loktak. The higher lecanid richness compares with the reports from the floodplains of Africa (Segers et al. 1993, 1998; Green 2003), Argentina (Jose de Paggi 2001), Brazil (Koste 1974; Koste & Robertson 1983; Bozelli 1992; Bonecker et al. 1998; Martinez et al. 2000; Serafim Jr. et al. 2003; Bonecker et al. 2005, 2009), Venezuela (Vásquez & Rey 1989), Thailand (Sanoamuang 1998), and India (Sharma & Sharma 2014a, 2014b; Sharma et al. 2017). Nevertheless, the relative paucity of the Brachionidae (20 species) in Loktak basin is in contrast to the above listed studies and the report from the Brahmaputra floodplains of NEI (Sharma & Sharma 2014b).

Our results ascertain the collective importance (~52% of species) of the littoral-periphytonic *Lecane* (57 species) > *Lepadella* (25 species) > *Trichocerca* (18 species). The consistency of the importance of these genera

in the Loktak basin highlights the possibility of rules for the periphytic rotifer assemblages as hypothesized by Green (2003). The relative significance of these taxa concurs with the reports from the floodplains of Argentina (Jose De Paggi 2001), Africa (Segers et al. 1993; Green loc cit.), Brazil (Koste 1974; Koste & Robertson 1983; Bonecker et al. 1998), Thailand (Segers & Pholpunthin 1997; Sanoamuang 1998), and Bolivia (Segers et al. 1998) as well as of Assam state of NEI (Sharma 2014; Sharma & Sharma 2008, 2014a, 2017). High richness of ‘tropic centered’ *Lecane* also concurred with several reports on the tropical rotifer faunas, i.e., Koste & Shiel (1983), Dussart et al. (1984), Bozelli (1992), Bonecker et al. (1994), Segers (1995), and Sharma & Sharma (2008, 2014a, 2017).

Loktak Rotifera indicates a number of small-sized littoral-periphytonic species of *Colurella*, *Lecane*, *Lepadella* and *Trichocerca*; this feature is hypothesized to result from predation influence of juvenile fish and invertebrates (Baumgartner et al. 1997) though specific studies are needed to confirm this hypotheses. Our collections exhibit the paucity of planktonic rotifers and that of *Brachionus* (10 spp.), *Filinia*, *Hexarthra* and *Conochilus* species in particular. The occurrence of fewer *Brachionus* species corresponds with our reports from the floodplains of the Majuli River Island (Sharma 2014) and the Dibru-Saikhowa Biosphere reserve (Sharma et al. 2017) of upper Assam, NEI. Sharma et al. (2017) proposed the L/B quotient based on *Lecane/Brachionus* species ratios to characterize habitat variations of wetlands of lower Assam, NEI. Based on overall richness of the two genera, the L/B quotient for Loktak Lake indicates a value of 5.7 thus ascertaining ‘wetland character’ of this Ramsar site; this is affirmed by the littoral-periphytic nature of the lake system with a lack of permanent open-water limnetic conditions.

The morphological variability observed in certain species from Loktak Lake, namely *Lepadella ovalis*, *L. patella*, *Lecane bulla*, *L. curvicornis*, *L. hamata*, *L. leontina*, *L. luna*, *L. lunaris*, *L. quadridentata*, *L. unguata*, *Testudinella emarginula*, *T. patina*, *T. tridentata* and *Platyonus patulus* needs attention for cryptic diversity analysis in light of some interesting studies on such species complexes (Suatoni et al. 2006; Schröder & Walsh 2010; Montero-Pau et al. 2011; Mills et al. 2017).

To sum up, the designation of Loktak Lake as a Rotifera hot-spot of the Indian sub-region, new records, and species of global and regional biogeographic interest highlight the biodiversity and ecosystem diversity importance of this Ramsar site. Our intensive sampling and the results justify this revisit of Loktak Lake with regards its importance to biodiversity and biogeography of the Indian Rotifera. We, however, estimate an occurrence of 270+ species of the phylum from this floodplain lake system pending specific analysis of periphytic, colonial and



benthic taxa, the rotifer-macrophytic associations relating to the characteristic ‘phumdi’, and analysis of cryptic diversity of certain species complexes.

**Acknowledgements.** The senior author thanks the Head, Department of Zoology, North-Eastern Hill University, Shillong for laboratory facilities and various researchers and well-wishers for untiring help in the field work. We thank our anonymous peers for useful comments and suggestions. We wish to thank Ralph S. Peters and Bernhard Huber (Bonn zoological Bulletin) for useful suggestions during the peer review. The authors have no conflict of interests.

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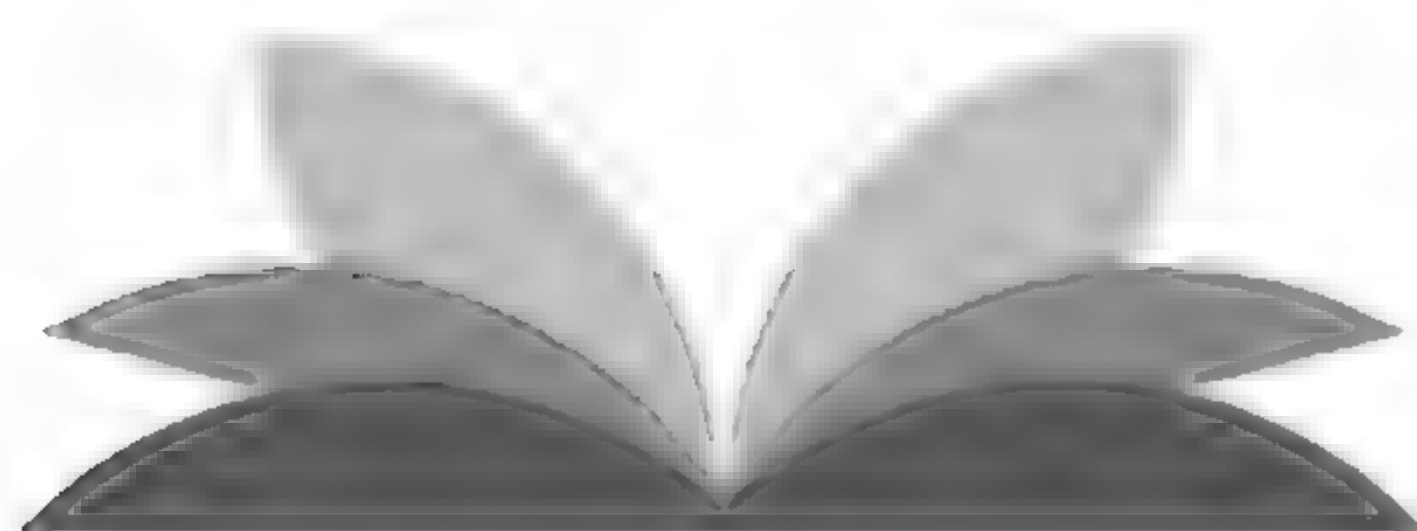
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## New records of snakes (Squamata: Serpentes) from Hoa Binh Province, northwestern Vietnam

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**Abstract.** We report nine new records of snakes from Hoa Binh Province based on a reptile collection from Thuong Tien, Hang Kia-Pa Co, Ngoc Son-Ngo Luong nature reserves, and Tan Lac District, comprising six species of Colubridae (*Dryocalamus davisonii*, *Euprepiophis mandarinus*, *Lycodon futsingensis*, *L. meridionalis*, *Sibynophis collaris* and *Sinonatrix aequifasciata*), one species of Pareatidae (*Pareas hamptoni*) and two species of Viperidae (*Protobothrops mucrosquamatus* and *Trimeresurus gumprechtii*). In addition, we provide an updated list of 43 snake species from Hoa Binh Province. The snake fauna of Hoa Binh contains some species of conservation concern with seven species listed in the Governmental Decree No. 32/2006/ND-CP (2006), nine species listed in the Vietnam Red Data Book (2007), and three species listed in the IUCN Red List (2018).

**Key words.** New records, snakes, taxonomy, Hoa Binh Province.

### INTRODUCTION

In the recent checklist of the herpetofauna of Vietnam, Nguyen et al. (2009) listed 192 species of snakes. Since then 13 new country records, one new genus and 15 new species of snakes have been described from Vietnam (Ziegler & Nguyen 2010, Uetz et al. 2018). In Hoa Binh Province, previous studies documented a total of 34 species of snakes (Nguyen et al. 2009, Nguyen et al. 2010, Ziegler et al. 2010, Luu et al. 2011). In this paper, we report nine new records of snakes from Hoa Binh Province based on newly collected specimens from Thuong Tien Nature Reserve (Kim Boi District), Hang Kia-Pa Co Nature Reserve (Mai Chau District), Ngoc Son-Ngo Luong Nature Reserve (Tan Lac and Lac Son districts), and Tan Lac District.

### MATERIAL & METHODS

Field surveys were conducted in Thuong Tien Nature Reserve (hereafter NR) by V.Q. Luu in March 2009; in Hang Kia-Pa Co and Ngoc Son-Ngo Luong NR, in April, May, September, and October 2014 and April 2015 by T.Q. Nguyen, C.T. Pham, C.V. Hoang, H.N. Ngo, M.D. Le, H.T. An (hereafter TQN et al.) and in Tan Lac District in June 2016 by C.T. Pham, T.V. Nguyen, N.H. Nguyen

(hereafter CTP et al.). Specimens were collected by hand or by using a snake hook between 8:00 and 23:00 hrs. Most specimens were photographed in life. Specimens were euthanized in a closed vessel with a piece of cotton wool containing ethyl acetate (Simmons, 2002), fixed in 85% ethanol and subsequently stored in 70% ethanol. Tissue samples of some species were kept separately in 90% ethanol. Specimens were deposited in the collections of the Institute of Ecology and Biological Resources (IEBR), Vietnam Academy of Science and Technology, Hanoi, Vietnam.

Taxonomic identifications of the specimens were made based on the following literature: Smith (1943), Taylor (1965), David et al. (2002), Vogel et al. (2004), Gumprecht et al. (2004), Orlov et al. (2004, 2011), Kim & Oh (2006), Stuart & Heatwole (2008), Yang et al. (2008), Vogel et al. (2009), Hecht et al. (2013), Luu et al. (2013a, b), Le et al. (2015), Nguyen et al. (2011, 2014), Ziegler et al. (2007, 2014), Nemes et al. (2013), Nguyen et al. (2016), Vassilieva et al. (2016), and Pham et al. (2017). For common names, we followed Nguyen et al. (2009) and Uetz et al. (2018). Abbreviations used for morphometry are as follows: SVL (snout-vent length): from tip of snout to anterior margin of cloaca; TaL (tail length): from posterior margin of cloaca to tip of tail.

Identification of sex was performed by dissection (inspection of gonads and inspection of presence of hemi-





**Fig. 1.** Map showing the survey site (black square) in Hoa Binh Province, Vietnam.



penes). Measurements were taken after preservation with a measuring tape. The number of ventral scales was counted according to Dowling (1951). The numbers of dorsal scale rows are given at one head length behind head, at midbody, and at one head length before vent, respectively. Scalation was studied by using a binocular. Bilateral scale counts were given as left/right.

## RESULTS

### Taxonomic accounts

#### Family Colubridae

##### *Dryocalamus davisonii* (Blanford, 1878)

Bridle Snake / Rắn dẽ (Fig. 2a)

Specimen examined (n = 1): IEBR 4058 (adult female) collected by TQN et al. on 22 May 2014, in Ngoc Son-Ngo Luong NR, Lac Son District (20°24.909'N, 105°19.102'E; elevation 350 m above sea level [hereafter asl.]).

Description: Morphological characters of the specimen from Hoa Binh Province agreed well with the descriptions of Smith (1943), Taylor (1965), Das (2010), Orlov et al. (2011), and Vassilieva et al. (2015). SVL 587.7 mm, TaL 191.4 mm. Head distinct from neck; nasal undivided; loreal 1/1, touching the eye; preocular absent; postoculars 2/2; anterior temporal 1/1; posterior temporals 2/2; supralabials 7/7, third and fourth entering orbit; infralabials 8/8; dorsal scale rows 13–13–13, all smooth; ventrals 239 (+ 1 preventral); cloacal undivided; subcaudals 109, divided.

Coloration in life: Dorsum black with 45 white cross-bars and 26 other bars on tail; white cross-bar narrower at posterior part of body; head dark brown with pale cream-colored elongated spots on each side, from parietal shield to supraorbital; venter cream anteriorly, grey posteriorly.

Ecological notes: The specimen was found at 22:00 on the ground. The surrounding habitat was secondary forest composed of medium and small hardwoods and shrub.

Distribution: In Vietnam, this species has been recorded from Thanh Hoa Province southwards to Kien Giang Province. This is the first record of *D. davisonii* from Ngoc Son-Ngo Luong NR as well as from Hoa Binh Province and the Northwest of Vietnam. Elsewhere, the species has been reported from Myanmar, Laos, Thailand and Cambodia (Nguyen et al. 2009, Orlov et al. 2011).

##### *Euprepiophis mandarinus* (Cantor, 1842)

Mandarin Ratsnake / Rắn sọc quan (Fig. 2b)

Specimen examined (n = 1): Photographic record only, by T.Q. Nguyen on 12 April 2014, in Hang Kia-Pa Co

NR, Mai Chau District (20°43.445'N, 104°53.310'E; elevation 1381 m asl.).

Description: Morphological characters of the specimen from Hoa Binh Province agreed well with the descriptions of Smith (1943), Yang & Rao (2008), Das (2010), and Ziegler et al. (2014). The photographed specimen resembles *Euprepiophis mandarinus* in the following characters: Dorsum brown above, with a series of large black, diamond shaped marks that enclose oval, rounded or squarish yellow spots; black marks edged by narrow yellow margins; head with three black marking-bands across snout, a crescent V-shaped mark through the eye and divided into two stripes, and a forward pointing shaped mark on the neck.

Ecological notes: The specimen was found at 21:30 on the ground, on the banks of a rocky stream. The surrounding habitat was secondary forest composed of medium and small hardwoods and shrub.

Distribution: In Vietnam, this species has been recorded from Lai Chau and Ha Giang provinces in the North southwards to Dak Lak Province. This is the first record of *E. mandarinus* from Hang Kia-Pa Co NR as well as from Hoa Binh Province. Elsewhere, the species has been reported from India, China, Taiwan, Myanmar and Laos (Nguyen et al. 2009, Ziegler et al. 2014).

##### *Lycodon futsingensis* (Pope, 1928)

Futsing Wolf Snake / Rắn khuyết fut-sing (Fig. 2c)

Specimen examined (n = 1): IEBR 4171 (juvenile) collected by TQN et al. on 14 April 2014, in Hang Kia-Pa Co NR, Mai Chau District (20°43.667'N, 104°51.823'E; elevation 901 m asl.).

Description: Morphological characters of the specimen from Hoa Binh Province agreed well with the descriptions of Vogel et al. (2009), Hecht et al. (2013), Luu et al. (2013), Nguyen et al. (2014), Nguyen et al. (2016), and Pham et al. (2017). SVL 265.9 mm, TaL 75.7 mm. Head distinct from neck; rostral broader than high; internasal not in contact with loreal; nasal divided; loreal 1/1, small, not touching the eye; preocular 1/1; subocular absent; postoculars 2/2; anterior temporals 2/2; posterior temporals 2/2; supralabials 8/8, third to fifth entering orbit; infralabials 10/10; dorsal scale rows 17–17–15, all smooth; ventrals 202 (+ 1 preventral); cloacal undivided; subcaudals 90, divided.

Coloration in life: Dorsum pale brownish grey with 27 brown rings on body and 8 rings on the tail; head dark brown with a large light band, from eye to neck; the rings wider at base, the first one starting at ventral scale 15, at its base comprising 6 ventrals in width and dorsally comprising 2 dorsal scales; venter cream, with dark marbling, dark grey posteriorly.

Ecological notes: The specimen was found at 21:00 on a forest path. The surrounding habitat was secondary forest composed of small hardwoods, liane and shrub.





**Fig. 2.** a) *Dryocalamus davisonii* (IEBR 4058), b) *Euprepophis mandarinus*, c) *Lycodon futsingensis* (IEBR 4171), d) *Lycodon meridionalis* (IEBR 4151), e) *Sinonatrix aequifasciata* (IEBR 4226), and f) *Sibynophis collaris* (IEBR 4224) from Hoa Binh Province, Vietnam.

**Distribution.** In Vietnam, this species was reported from Lao Cai Province in the North southwards to Da Nang City. This is the first record of *L. futsingensis* from Hang Kia-Pa Co NR as well as from Hoa Binh Province. Elsewhere, the species has been reported from China and Laos (Nguyen et al. 2009, Luu et al. 2013, Nguyen et al. 2016, Pham et al. 2017).

***Lycodon meridionalis* (Bourret, 1935)**

Southern Big-tooth Snake / Rắn lếch đầu kim tuyến (Fig. 2d)

Specimens examined (n = 4): IEBR 4050, 4051 (two adult males), and IEBR 4156 (adult female) collected by TQN et al. in April 2014, in Hang Kia-Pa Co NR, Mai Chau District (20°25.072'N, 105°19.102'E; elevation



300 m asl.); and IEBR 4154 (adult male) collected by CTP et al. on 19 June 2016, in Ngoc Son-Ngo Luong NR, Lac Son District (20°28.076'N, 105°18.216'E; elevation 733 m asl.)

Description: Morphological characters of the specimens from Hoa Binh Province agreed well with the descriptions of Orlov & Ryabov (2004), Hecht et al. (2013), Ziegler et al. (2014), and Nguyen et al. (2016). SVL: 929.5–1341.7 mm in males ( $n = 3$ ), 873.1 mm in the single female ( $n = 1$ ), TaL: 246.7–364.8 mm in males ( $n = 3$ ), 258.7 mm in the single female ( $n = 1$ ). Head distinct from neck; internasals not in contact with loreal; nasal divided; loreal 1/1, not touching the eye; preocular 1/1; subocular absent; postoculars 2/2; anterior temporals 2/2; posterior temporals 3/3; supralabials 8/8, third to fifth entering orbit; infralabials 10/10; dorsal scale rows 17–17–15, strongly keeled except 5 outermost rows smooth, outer dorsal scales enlarged; ventrals 242–257 (+ 2–3 preventrals); cloacal undivided; subcaudals 100–118, divided.

Coloration in life: Dorsum black with 100–119 narrow yellow cross-bars on body and 31–41 on tail, bifurcated on the sides, enclosing dark spots; head black with symmetrical light markings, the most conspicuous being the one running from the eye to the margin of the snout and another stretching from the hind margin of the parietals; venter light yellow.

Ecological notes: The specimens were found between 19:00 and 22:30, on the ground or on rocks. The surrounding habitat was secondary forest composed of medium and small hardwoods, liane and shrub.

Distribution: In Vietnam, this species has been reported from Lao Cai and Ha Giang provinces in the North southwards to Thanh Hoa Province. This is the first record of *L. meridionalis* from Hang Kia-Pa Co and Ngoc Son-Ngo Luong NRs as well as from Hoa Binh Province. Elsewhere, the species has been reported from China and Laos (Nguyen et al. 2009, Ziegler et al. 2014, Nguyen et al. 2016).

### ***Sibynophis collaris* (Gray, 1853)**

Common Many-tooth Snake / Rắn rỗng cổ đen (Fig. 2e)

Specimen examined ( $n = 1$ ): IEBR 4224 (adult female) collected by V.Q. Luu in March 2009, in Thuong Tien NR, Kim Boi District (near 20°36'N, 105°29'E; elevation 608 m asl.).

Description: Morphological characters of the specimen from Hoa Binh Province agreed well with the descriptions of Smith (1943), Taylor (1965), Kim & Oh (2006), Nemes et al. (2013), and Vassilieva et al. (2015). SVL 324 mm, TaL 184 mm. Head distinct from neck; internasal not in contact with loreal; nasal divided; loreal 1/1, small, not touching the eye; preocular 1/1; subocular absent; postoculars 2/2; anterior temporal 1/1; posterior temporals 2/2; supralabials 10/10, fourth to sixth enter-

ing orbit; infralabials 9/9; dorsal scale rows 17–17–17, all smooth; ventrals 168 (+ 1 preventral); cloacal divided; subcaudals 120, divided.

Coloration in preservative: Dorsum brown, with a vertebral series of small black spots, light dorsolateral lines mostly present; head black with a black stripe running from neck to the back of the head; a white stripe along supralabials to the neck; venter yellow, each ventral with a lateral dark spot.

Distribution. In Vietnam, this species has been reported from Dien Bien and Son La provinces in the North southwards to Lam Dong and Dong Nai provinces. This is the first record of *S. collaris* from Thuong Tien NR as well as from Hoa Binh Province. Elsewhere, the species has been reported from India, Nepal, China, Taiwan, Korea, Laos, Thailand, Cambodia, and Malaysia (Kim & Oh 2006, Nguyen et al. 2009, Nemes et al. 2013, Vassilieva et al. 2015).

### ***Sinonatrix aequifasciata* (Barbour, 1908)**

Asiatic Water Snake / Rắn hoa cân vân đốm (Fig. 2f)

Specimens examined ( $n = 2$ ). IEBR 4225 (adult male) and IEBR 4226 (adult female) collected by TQN et al. on 17 April 2015, in Ngoc Son-Ngo Luong NR, Lac Son District (20°26.671'N, 105°16.139'E; elevation 250 m asl.).

Description: Morphological characters of the specimens from Hoa Binh Province agreed well with the descriptions of Vogel et al. (2004), Stuart & Heatwole (2008), Hecht et al. (2013), and Le et al. (2015). IEBR 4225: SVL 666.9 mm, TaL 208.3 mm; IEBR 4226: SVL 729.1 mm, TaL 236.1 mm. Head elongated, indistinct from neck; nuchal groove distinct; loreal present; preoculars 1/1 or 2/2; postoculars 3/4 or 3/5; anterior temporals 2/2, posterior temporals 2/3 or 3/3; supralabials 9/9, the fifth entering orbit, the seventh largest; infralabials 10/10; dorsal scale rows 19–19–17, strongly keeled; ventrals 144–153 (+ 2–3 preventrals); cloacal divided; subcaudals 70–74, divided.

Coloration in life: Dorsal surface with 21 black double-bands on body, flanks with dark markings, in X-shape and 10–12 on tail; interspaces with brownish tinge on each band, narrower than the dark bars; venter cream with black markings.

Ecological notes: The specimens were found between 19:00 and 21:30, on branches of trees, about 1.0–1.5 m above the ground, on the banks of a rocky stream. The surrounding habitat was secondary forest composed of medium and small hardwoods, liane and shrub.

Distribution: In Vietnam, this species has been reported from Lao Cai and Ha Giang provinces in the North southwards to Nghe An and Ha Tinh provinces. This is the first record of *S. aequifasciata* from Ngoc Son-Ngo Luong NR as well as from Hoa Binh Province. Elsewhere, the species has been reported from China and Laos (Stuart



et al. 2008, Nguyen et al. 2009, Hecth et al. 2013, Le et al. 2015).

### Family Pareatidae

#### *Pareas hamptoni* (Boulenger, 1905)

Hampton's Slug Snake / Rắn hổ mây ham-ton (Fig. 3a)

Specimens examined (n = 2): IEBR 4227, 4228 (adult males) collected by TQN et al. in October 2014, in Ngoc Son-Ngo Luong NR, Lac Son District (20°26.862'N, 105°20.144'E; elevation 553 m asl.)

Description: Morphological characters of the specimens from Hoa Binh Province agreed well with the descriptions of Smith (1943), Taylor (1965), Ziegler et al. (2007), Nguyen et al. (2011), and Nemes et al. (2013). SVL 363–524 mm, TaL 108–179 mm (n = 2). Body strongly compressed; head distinct from neck; nasal undivided; loreal 1/1, touching the eye; preocular 1/1; postoculars 1/1; subocular 1, long and slender, separating the eye from the labials; anterior temporal 1/1; posterior temporals 2/2; supralabials 7/7, third to fifth below the eye, seventh very long; infralabials 8/8; mental groove absent; dorsal scale rows 15–15–15, all smooth except posterior upper dorsal scales slightly keeled, anterior vertebral scales slightly enlarged; ventrals 199–202 (+ 1 pre-ventral); cloacal undivided; subcaudals 98–100, divided.

Coloration in life: Light brown dorsally, with dorso-lateral rows of alternating spots, forming a zigzag line, spots absent at the margin of the ventrals.

Ecological notes: The specimens were found between 19:00 and 22:30 on branches of trees, about 1.5–2.0 m above the ground, on forest paths. The surrounding habitat was secondary forest composed of medium and small hardwoods, liane and shrub.

Distribution: In Vietnam, this species has been reported from Lao Cai and Ha Giang provinces in the North southwards to Lam Dong and Dong Nai provinces. This is the first record of *P. hamptoni* from Ngoc Son-Ngo Luong NR as well as from Hoa Binh Province. Elsewhere, the species has been reported from China, Myanmar, Laos, and Cambodia (Nguyen et al. 2009).

### Family Viperidae

#### *Protobothrops mucrosquamatus* (Cantor, 1839)

Brown spotted pitviper / Rắn lục cườm (Fig. 3b, c)

Specimens examined (n = 2): IEBR 4230 (adult male) collected by C.V. Hoang in Ngoc Son-Ngo Luong NR, Lac Son District (20°25.034'N, 105°23.107'E; elevation 440 m asl.) and IEBR 4231 (adult female) collected by C.T. Pham et al. on 8 June 2016, in Thanh Hoi Commune, Tan Lac District (20°34.865'N, 105°19.731'E; elevation 170 m asl.).

Description: Morphological characters of the specimens from Hoa Binh agreed well with the description of Stuart & Heatwole (2008), Nguyen et al. (2011), Luu et al. (2013), and Nemes et al. (2013). IEBR 4230: SVL 544.0 mm, TaL 129 mm; IEBR 4231: SVL 605.3 mm, TaL 134.0 mm. Hemipenes short and thick. Head triangular, clearly distinct from the neck; nasal undivided; internasals separated from each other by three scales; two small scales between the nasal and the shield bordering the anterior region of the loreal pit; postoculars 2/2; supralabials 8/8 or 11/11, the first supralabial completely separated from the nasal, third supralabial large, in contact with the subocular, fourth and fifth supralabials separated from the subocular by two scales; temporals small; infralabials 13/14, the first pair in contact with each other, the first three pairs in contact with the chin shields; dorsal scale rows 23(25)–23–17(21), rhomboid, strongly keeled throughout but smooth on the first outer row; ventrals 203–214 (+ 2 pre-ventrals); cloacal undivided; subcaudals 88–97, divided.

Coloration in life: Dorsal head brown, paler below; dorsum greyish brown, with a series of large brown, dark-edged spots; a dark brown line from the eye to the angle of the mouth, edged in black; ventral surface brownish with white blotches; dorsal tail light brown, with a series of conspicuous black spots.

Ecological notes: The specimens were found between 19:00 and 22:30, on forest paths. The surrounding habitat was secondary forest composed of medium and small hardwoods, liane and shrub.

Distribution: In Vietnam, this species has been reported from Lao Cai and Ha Giang provinces in the North southwards to Kon Tum and Gia Lai provinces. This is the first record of *P. mucrosquamatus* from Ngoc Son-Ngo Luong NR as well as from Hoa Binh Province. Elsewhere, the species has been reported from India, Bangladesh, China, Taiwan, and Myanmar (Nguyen et al. 2009, Luu et al. 2013, Nemes et al. 2013).

#### *Trimeresurus gumprehti* David, Vogel, Pauwels & Vidal, 2002

Gumprecht's green pitviper / Rắn lục gum-p-ret (Fig. 3d)

Specimen examined (n = 1): IEBR 3918 (subadult male) collected by TQN et al. on 12 April 2014, in Hang Kia-Pa Co NR, Mai Chau District (20°44.184'N; 104°53.362'E, elevation 1201 m asl.)

Description: Morphological characters of the specimen from Hoa Binh agreed well with the description of David et al. (2002). SVL 441.75 mm, TaL 100 mm. Hemipenes short and thick with spines. Head triangular, clearly distinct from the neck; rostral visible from above, triangular; nasal undivided; internasals separated from each other by a scale; two small scales between the nasal and the shield bordering the anterior region of the loreal pit; postoculars 2/2; supralabials 10/10, the first separated from the





**Fig. 3.** a) *Pareas hamptoni* (IEBR 4227), b) *Protobothrops mucrosquamatus* (male) (IEBR 4230) and c) female (IEBR 4231), and d) *Trimeresurus gumprechtii* (IEBR 3918) from Hoa Binh Province, Vietnam..

nasal, third large, in contact with subocular, fourth and fifth separated from subocular by a small scale; temporals small; infralabials 13/12, the first pair in contact with each other, the first three pairs in contact with the chin shields; dorsal scale rows 23–21–15, rhomboid, strongly keeled throughout but smooth on the outermost row; ventrals 160 (+ 4 preentrals); cloacal undivided; subcaudals 70, divided.

Coloration in life: Dorsal and ventral surface green with a white ventrolateral stripe, edged in red below; lateral head with a white postocular streak, edged in red below; tail green with upper part of posterior half rusty red; eyes red.

Ecological notes: The specimen was found at 21:00 on tree branches near a small stream, approximately 0.2 m above the ground. The surrounding habitat was secondary forest composed of medium and small hardwoods, liane and shrub. A tree frog (*Kurixalus* sp.) and a water

skein (*Tropidophorus* sp.) were found in the stomach of this specimen.

Distribution. In Vietnam, this species has been reported from Lai Chau and Lao Cai provinces (Nguyen et al. 2009). This is the first record of *T. gumprechtii* for Hang Kia-Pa Co NR as well as for Hoa Binh Province. Elsewhere, the species has been reported from China, Myanmar, Laos, and Thailand (David et al. 2004, Nguyen et al. 2009).

## DISCUSSION

Our new records of nine snake species bring the total number of snake species in Hoa Binh Province to 43 (Table 1). The most diverse family is Colubridae with 27 recorded species, followed by Elapidae (4 species) and Viperidae (4 species). The snake fauna of Hoa Binh



**Table 1.** List of snake species recorded from Hoa Binh Province, Vietnam. Data sources: 1: Nguyen et al. (2009), 2: Nguyen et al. (2010), 3: Ziegler et al. (2010), 4: Luu (2011), 5: This study. Decree 32 (2006) = Governmental Decree No 32/2006/ND-CP dated on 30 March 2006 by the Government of Vietnam on the management of endangered wild flora and fauna. Group IB: prohibited exploitation and use for commercial purpose and Group IIB: limited exploitation and use for commercial purpose; RBVN (2007) = Vietnam Red Data Book. Part I. Animals. Descriptions of nationally endangered species of wild animals. CR = Critically Endangered, EN = Endangered, VU = Vulnerable; IUCN (2018) = The IUCN Red List of Threatened Species. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, LR/nt = Lower Risk/Near Threatened, \* new provincial record.

Species name	Previous record	IUCN (2017)	RBVN (2007)	Decree 32 (2006)
<b>Pythonidae</b>				
<i>Python bivittatus</i> (Kuhl, 1820)	1	VU	CR	II B
<b>Xenopeltidae</b>				
<i>Xenopeltis unicolor</i> Reinwardt, 1827	1, 5			
<b>Colubridae</b>				
<i>Ahaetulla prasina</i> (Boie, 1827)	1, 4, 5			
<i>Amphiesmoides ornaticeps</i> (Werner, 1924)	2			
<i>Amphiesma stolatum</i> (Linnaeus, 1758)	1, 4, 5			
<i>Boiga kraepelini</i> Stejneger, 1902	3			
<i>Boiga multomaculata</i> (Boie, 1827)	1, 5			
<i>Calamaria pavementata</i> Duméril, Bibron & Duméril, 1854	1			
<i>Calamaria septentrionalis</i> Boulenger, 1890	1			
<i>Coelognathus radiatus</i> (Boie, 1827)	1, 5		VU	II B
<i>Cyclophiops multicinctus</i> (Roux, 1907)	1, 5			
<i>Dendrelaphis pictus</i> (Gmelin, 1789)	4			
<i>Dryocalamus davisonii</i> (Blanford, 1878)*	5			
<i>Elaphe moellendorffi</i> (Boettger, 1886)	1, 4, 5		VU	
<i>Euprepiophis mandarinus</i> (Cantor, 1842)*	5		VU	
<i>Lycodon futsingensis</i> (Pope, 1928)*	5			
<i>Lycodon meridionalis</i> (Bourret, 1935)*	5			
<i>Oligodon taeniatus</i> (Günther, 1861)	4			
<i>Opisthotropis lateralis</i> Boulenger, 1903	1			
<i>Plagiopholis nuchalis</i> (Boulenger, 1893)	1			
<i>Ptyas korros</i> (Schlegel, 1837)	1, 4, 5		EN	
<i>Ptyas mucosa</i> (Linnaeus, 1758)	1, 5		EN	II B
<i>Rhabdophis chrysargos</i> (Schlegel, 1837)	1			
<i>Rhabdophis subminiatus</i> (Schlegel, 1837)	1, 4, 5			
<i>Sibynophis chinensis</i> (Günther, 1889)	1, 4			
<i>Sibynophis collaris</i> (Gray, 1853)*	5			
<i>Sinonatrix aequifasciata</i> (Barbour, 1908)*	5			
<i>Sinonatrix percarinata</i> (Boulenger, 1899)	1, 5			
<i>Xenochrophis flavipunctatus</i> (Hallowell, 1860)	1, 4, 5			
<b>Elapidae</b>				
<i>Bungarus fasciatus</i> (Schneider, 1801)	1, 4, 5		EN	II B
<i>Bungarus multicinctus</i> Blyth, 1861	1, 4, 5			II B
<i>Naja atra</i> Cantor, 1842	1, 4	VU	EN	II B
<i>Ophiophagus hannah</i> (Cantor, 1836)	1, 4	VU	CR	I B
<b>Homalopsidae</b>				
<i>Hypsiscopus plumbea</i> (Boie, 1827)	1, 5			
<i>Myrrophis chinensis</i> (Gray, 1842)	1, 5			
<b>Lamprophiidae</b>				
<i>Psammodynastes pulverulentus</i> (Boie, 1827)	1			
<b>Pareatidae</b>				
<i>Pareas hamptoni</i> (Boulenger, 1905)*	5			
<i>Pareas macularius</i> Theobald, 1868	1, 5			
<i>Pareas margaritophorus</i> (Jan, 1866)	1, 5			
<b>Viperidae</b>				
<i>Protobothrops mucrosquamatus</i> (Cantor, 1839)*	5			
<i>Trimeresurus albolabris</i> (Gray, 1842)	1			
<i>Trimeresurus gumprechtii</i> David, Vogel, Pauwels & Vidal, 2002*	5			
<i>Trimeresurus stejnegeri</i> Schmidt, 1925	1			

Province also contains several species of conservation concern. Three species are listed in the IUCN Red List



(2018): *Python bivittatus*, *Naja atra* and *Ophiophagus hannah*, nine species are listed in the Red Data Book of Vietnam (2007): *Python bivittatus*, *Coelognathus radiatus*, *Elaphe moellendorffi*, *Euprepiophis mandarinus*, *Ptyas korros*, *P. mucosa*, *Bungarus fasciatus*, *Naja atra*, and *Ophiophagus hannah*; seven species are listed in the Vietnam Governmental Decree No. 32/2006/ND-CP (2006): *Python bivittatus*, *Coelognathus radiatus*, *Ptyas mucosa*, *Bungarus fasciatus*, *B. multicinctus*, *Naja atra*, and *Ophiophagus hannah* (see Table 1).

**Acknowledgements.** We are grateful to the directorates of the Forest Protection Department of Hoa Binh Province for their support of our field work and issuing relevant permits. We thank V.Q. Luu, H.T. An, C.V. Hoang, H.N. Ngo, M.D. Le, N.H. Nguyen (Hanoi) for their assistance in the field. We thank to E. Sterling (New York) and K. Koy (Berkeley) for providing the map. For the fruitful cooperation within joint amphibian projects we cordially thank S.V. Nguyen (IEBR, Hanoi) and T. Pagel and C. Landsberg (Cologne Zoo). This research is supported by the National Foundation for Science and Technology Development (NAFOSTED, Grant No. 106.05-2017.329).

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# Taxonomic reassessment of the Common Indian Wolf Snakes *Lycodon aulicus* (Linnaeus, 1758) complex (Squamata: Serpentes: Colubridae)

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**Abstract.** We studied the population systematics of the group of the Common Indian wolf snake (*Lycodon aulicus* s. lat.) based on a series of specimens from throughout most of their geographic range. Two discrete species-groups could be discerned based on head dimensions, collar band pattern, hemipenial morphology and frontal-preocular-prefrontal-supraocular scale contact configurations (with outliers). The first one contains specimens agreeing with the morphology of the name-bearing type of *Lycodon aulicus*; the other includes specimens agreeing with the morphology of *Lycodon anamallensis* (so far within the synonymy of *L. aulicus*), which is here revalidated at species-level. We formally report the presence of the presumed Sri Lankan endemic *Lycodon osmanhilli* group taxa in the Indian peninsula and we synonymise *L. osmanhilli* with the senior nomen *L. anamallensis* which is based on an Indian specimen. Our series of specimens show clear and sometimes non-overlapping geographical variations in ventral, subcaudal scale counts and relative tail lengths within both species.

**Key words.** Collar band, head dimension, Indian peninsula, Sri Lanka, Wolf Snakes.

## INTRODUCTION

The common Indian wolf snake *Lycodon aulicus* (Linnaeus, 1758) is a non-venomous, mainly nocturnal, oviparous colubrid snake found in the Indian subcontinent (Whitaker & Captain 2004). It is one of the commonest and most ‘well-known’ snakes in tropical Asia. It was described by Carolus Linnaeus in his *Systema Naturae*. Subsequently, Patrick Russell, the “father of Indian Ophiology”, included this species in his treatise (Russell 1796). It is understood to be widespread, human-commensally and common in almost all herpetological literature (e.g., Whitaker & Captain 2004). But yet, as often the case with such ‘well-known’ South Asian snakes like the Rock Python *Python molurus* (see Wulf & O’Shea 2010), the Spectacled Cobra *Naja naja* (see Wüster 1998a), the Russell’s Viper *Daboia russelii* (see Wüster 1998 b), the Bronzeback Tree Snake *Dendrelaphis tristis* (see Vogel & Van Rooijen 2009) and the Keelbacks *Xenochrophis piscator* and *Amphiesma stolatum* (see Vogel & David 2012; Guo et al. 2014), the taxonomy of *Lycodon aulicus* is still far from being resolved and the variation is not well known.

This species was originally described based on the holotype NHR Lin-21 (formerly MAFR), a 250 mm long specimen (Mus. Drott.) supposed to come from “America”. The type specimen is still extant in the Royal Museum of Stockholm, formerly the Museum Adolphi FridERICI. The type locality was later proved to be in error and was corrected to ‘India’ by Kramer (1977). Laurenti (1768) allocated this species to the genus *Natrix*, as *Na-*

*trix aulica*. Duméril et al. (1854) transferred *Natrix aulica* to the genus *Lycodon*, as *Lycodon aulicum*.

Cantor (1839) described *Lycodon subfuscus* based on a single specimen from Bengal, in north-eastern India. Cantor (1839) also described *Lycodon atropurpureus* based on a single specimen from “Mergui”, now Myeik, in southern Myanmar. Günther (1864) described *Lycodon anamallensis* based on a single specimen from the Anamallay Hills of the Western Ghats, in peninsular India. Later Wall (1909) described the subspecies *Lycodon aulicus oligozonatus* based on specimens from Cannanore (in Malabar Coast) and Bellary (in Deccan plateau), in southern India. All these four nomina were synonymised by Smith (1943) with *Lycodon aulicus* (Linnaeus, 1758). Taylor (1950) described *Lycodon osmanhilli* based on two specimens (a holotype and a paratype) from Colombo in Sri Lanka. Günther (1864) and Boulenger (1893) listed several ‘varieties’ of *L. aulicus*. As can be seen from the list of synonyms which were based on specimens from ‘India’, Bengal, Colombo and Mergui and the generic transfers from across late 18<sup>th</sup> century to mid 20<sup>th</sup> century (Wallach et al. 2014), the *Lycodon aulicus* complex has had a rather controversial taxonomic and nomenclatural history.

Except for *Lycodon osmanhilli*, all of the above-mentioned nomina are currently considered to be subjective junior synonyms of *Lycodon aulicus* (see, for example, Whitaker & Captain 2004; Uetz 2016). Wallach et al. (2014) considered *L. osmanhilli* a synonym of *L. aulicus* as well, but other authors (Das & De Silva 2005; Somaweera 2006) considered it a valid species. While the validity of *Lycodon osmanhilli* is still being discussed,



recently Pyron et al. (2013), in their molecular phylogeny, showed that *Lycodon osmanhilli* is distinct from *L. aulicus*. Their phylogenetic tree revealed that *L. aulicus* is the sister taxon of *L. zawi* Slowinski, Pawar, Win, Thin, Gyi, Oo & Tun, 2001 from the Indoburmese region, while *L. osmanhilli* is the sister taxon of *L. capucinus* (Boie, 1827) of Southeast Asia (Pyron et al. 2013). Siler et al. (2013) even synonymized *L. capucinus* with *L. aulicus*, although they did not examine Indian or Sri Lankan material, a hypothesis not followed here and by later workers (Vogel & Harikrishnan 2013; Wallach et al. 2014).

Ganesh & Chandramouli (2011) remarked on two syntopic morphotypes of the *Lycodon aulicus* complex from Coromandel Coast and enumerated morphological differences. They pointed out differences in general body colouration, head dimensions and band pattern between the two morphotypes and stated that one of the morphs resembled the Sri Lankan endemic *L. osmanhilli*. Our further examination of a series of preserved specimens from several localities, including the type specimens, revealed consistent differences, as suggested earlier (Ganesh & Chandramouli 2011). In this work, we reassess the systematics of *Lycodon aulicus* sensu auctorum and provide formal taxonomic and nomenclatural implications.

## MATERIALS & METHODS

For this study we investigated a total of 74 specimens of the complex of *Lycodon aulicus* originating from Mauritius and Pakistan in the west, across India on to Myanmar in the east, Nepal in the north and Sri Lanka in the south, thus essentially covering the Indian subcontinent. Several live examples were also examined. Specimens were examined for external morphological characters. Forty-four morphological characters were recorded for each specimen. Not all of these characters were useful to distinguish between species in this study, but all of them were compared because they may be useful for further taxonomic actions. Measurements, except body and tail lengths, were taken with a slide-caliper to the nearest 0.1 mm; all body measurements were made to the nearest millimetre. The number of ventral scales was counted according to Dowling (1951). Hemipenial morphological definitions and terminologies follow Dowling & Savage (1960). Half ventrals were counted as one. The first scale under the tail meeting its opposite was regarded as the first subcaudal, the terminal scute was not included in the number of subcaudals. The dorsal scale rows were counted at one head length behind head, at midbody (i.e., at the level of the ventral plate corresponding to a half of the total number of ventrals), and at one head length before vent. We considered infralabials being those shields that were completely below a supralabial. Values for paired

head characters are given in left/right order. Temporal scales were defined as the scales of which more than half of the area lies in front of an imaginary line that extends from the apex of the last supralabial to the posterolateral corner of the parietal. Ratio of the length of (complete) tail to the total length of the snake (i.e., from snout tip to tail tip) is calculated as relative tail length. The pale bands on the body and tail were counted on one side, usually the right side. Hardly visible or incomplete bands were counted as one band; bands that were fused (often forming an “X”) were counted as two. The collar on the neck was not counted and bands covering the anal shield were added to the bands of the body. Sex of preserved specimens was determined by dissection of the ventral tail base, while that of live individuals was examined to the extent possible by gentle anal palpation. Statistical tests were carried out in MS Office Excel and PAST software (Hammer et al. 2000).

**Abbreviations.** Avg. – average; BMNH: The Natural History Museum, London, UK. – CAS: California Academy of Sciences Museum, California, USA. – CSPT/S: Chennai Snake Park Museum, Chennai, India. – FMNH: Field Museum of Natural History, Chicago, USA. – NHMW: Naturhistorisches Museum Wien, Vienna, Austria. – MHNG: Muséum d’Histoire Naturelle, Geneva, Switzerland. – SMF: Naturmuseum Senckenberg, Frankfurt Am Main, Germany. – UPZM: Univ. of Peradeniya Zoology Museum, Sri Lanka. – ZFMK: Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany. – ZMB: Zoologisches Museum Berlin, Germany.

## SYSTEMATICS

### *Lycodon aulicus* (Linnaeus, 1758)

*Coluber aulicus* Linnaeus, 1758

*Natrix aulica* – Laurenti, 1768

*Lycodon subfuscus* Cantor, 1839

*Lycodon atropurpureus* Cantor, 1839

*Lycodon aulicum* – Duméril, Bibron & Duméril, 1854

*Lycodon aulicus oligozonatus* Wall, 1909

*Ophites aulicus* – Wall, 1921

*Lycodon aulicus* – Smith, 1943; Daniel, 2002;

Whitaker & Captain, 2004; Goonawardene et al. 2006

*Lycodon travancoricus* (not of Beddome, 1871) –

Rao et al. (2005)

*Lycodon aulicus* morph1 – Ganesh & Chandramouli, 2011

*Lycodon aulicus* – (in part.) Wallach et al. (2014)

**Material examined.** *Males* ( $n=25$ ): **Myanmar:** NHMW 21699.1 Bhamo; CAS 215387 Sagaing; **Nepal:** FMNH 62427, Tansing; BMNH 1936.7.2.2 Mae Dist, Doons; BMNH 80.11.10.138 Nepal; **India:** BMNH 1908.5.23.15



Diburgash, Assam; FMNH 165108 Junganathpur, West Bengal; FMNH 8650 Central province near Chanda; FMNH 60647 Central province, Balaghat dist; BMNH 82.8.26.22 Kinelly (=Kimdey) hills, [Andhra Pradesh]; BMNH 74.4.29.958 Wynads, [Kerala] India; ZMB 1790 Bengal; BMNH 1904.10.18.5 Cannannore, Malabar; NHMW 37406:1 Ahmednagar, Maharashtra; NHMW 37406:2 Ahmednagar, Maharashtra; **Sri Lanka**: FMNH 123906 Ceylon; ZFMK 52137 Kitulgala; ZFMK 52511 Kitulgala; NHMW 21689:5–7 Sri Lanka; NHMW 14487:2–3 Sri Lanka; **Indian Ocean Islands**: ZFMK 29976 Mauritius; ZMB 8158 Isla Bourbon?; NHMW 21699.5 Ainoi islands in Hawaii.

**Females (n=34): Myanmar**: CAS 205000 DNA tested, Rakhin; CAS 245960 Tanintharyi; CAS 219800 Ayeyarwadi; NHMW 14483 Myanmar; ZMB 11625 Myanmar; NHMW 21702.2 Pegu, ; ZMB 10258 Minhla; BMNH 1928.1.4.1 Rangun; **Pakistan**: SMF 64484 Lahore, W-Pakistan; **Nepal**: BM 1984.1216 Royal Chitwan; FMNH 83090 Kathmandu; **India**: CAS-SU 12263 Bistrampur, Madhya Pradesh; FMNH 165107 West Bengal, Howrah Dist.; FMNH 161469 West Bengal, Barnijunoh; NHMW 14487.1 'Alakan'; ZMB 1791 Bengal; ZMB 9956 Ajmere, Rajasthan; ZMB 1806 Calcutta; NHMW 14488 Kolkata; BMNH 1921.6.15.3 Bangalore, Karnataka; SMF 32463 Agra; ZMB 1791 Bengal; BMNH 1955.1.3.11 Mysore, 3500 ft, Karnataka; BMNH 1936.1.3.4 Namakal, Tamil Nadu; BMNH 1924.10.13.9 Punakanaat, 700 ft, Travancore, Kerala; BMNH 69.8.28.94 Matheran, Maharashtra; **Sri Lanka**: FMNH 123907 Ceylon, Trincomalee; ZFMK 52510 Sri Lanka; NHMW 21689:1–3 Sri Lanka; NHMW 14487:1 Sri Lanka; **Indian Ocean Islands**: ZFMK 21766 Mascarenes, Reunion, Manapany; ZFMK 29977 Mauritius.

**Diagnosis (redefined herein).** A species of *Lycodon* inhabiting the Indian subcontinent, characterised by (1) a wide and large head, (2) a distinct creamy white collar-mark on head across parietal scales converging towards snout-tip, (3) a dark blackish-brown body with creamy white cross bars in life, (4) preocular usually contacting frontal, (5) supraocular usually not contacting prefrontal, (6) a fairly elongate hemipenis with smaller flounces and spines, (7) supralabials white, usually 9 on each side, (8) divided anal scale, (9) scale rows 17:17:15, (10) ventrals: 180–215 and subcaudals: 57–78 pairs, (11) relative tail length 0.15–0.20.

**Description and variation (Fig. 1).** A medium-sized (avg. 500 mm total length, our longest specimen was a female with 719 mm [BM 1924.10.13.9 from Punakanaat, 700 ft, Travacore, S India]) snake with heavy thick-set, stoutly built head and rather robust cylindrical trunk. Rostral scale scarcely visible from above; nasals small, sutured, in contact with 1<sup>st</sup> and 2<sup>nd</sup> supralabials; interna-

sals large, higher than broad; prefrontals vertically oblong, as large as frontal, in broad contact with loreal and preocular; anterior end of prefrontal not half as wide as posterior end, but only slightly smaller; frontal triangular, slightly larger than supraocular, usually in clear contact with preocular; anterior end of frontal not twice as wide as posterior end; supraocular not in contact with prefrontal; postoculars 2, small; temporals usually 2+3+3; supralabials usually 9, 3<sup>rd</sup> to 5<sup>th</sup> touching eye; parietals very large, subequal in length to its distance from internasals; infralabials horizontally elongate, 10–11; 1<sup>st</sup> to 5<sup>th</sup> touching genials; anterior genials larger than posterior genials; body scales smooth and glossy, imbricate, with mild apical pits; dorsal scales in 17:17:15 rows around body; preentrals usually 1–3; ventrals 180–205 (avg. 191.3) in males and 186–208 (avg. 199.4) in females, angulate laterally; anal scale divided; subcaudals 61–78 pairs (avg. 68.8) in males and 57–74 pairs (avg. 64.5) in females; relative tail length on average 0.186 in males (0.172–0.204) and 0.168 in females (0.146–0.191). Hemipenis fairly thin, cylindrical and short, extending up to 10<sup>th</sup> subcaudal scale, mildly forked near tip; pedicle slightly narrower than hemipenial lobe head; hemipenial head not quite bilobed; sulcal lips broader and ornamented with thick pointed spiny flounces, visible heavily on asulcate side and mildly on sulcate side. Sri Lankan specimens, in both the sexes, have shorter tails, and a lower number of ventral and subcaudals scales compared to peninsular Indian specimens and Indoburmese (here understood as the region from Northeast India upto Burmese peninsula) specimens that had the longest tails (see Table 1).

**Colouration in life.** Dorsum blackish-brown or dark brown, never without tinge of black; a series of about 8–40 creamy white cross bars either wholly complete across the dorsum, or broad on the vertebral row then diverging or disintegrating into two arms laterally; band width covers 2–4 dorsal body scales; interband distance typically covers 10–15 dorsal body scales; bands more thick and prominent on forebody, obscure or absent on hindbody, rarely completely absent, except for traces of white collar mark; underside, upper lip, lower lip, throat and chin pure white, slightly pinkish in juvenile specimens; tongue rosy pink; iris totally black, pupil not visible.

**Remarks.** Linnaeus (1758) is his original description of *Coluber aulicus*, mentioned 'vertex albus' meaning 'white crown of head' in Latin. The subsequent taxa described by Cantor (1839) were based on specimens in conformity with Linnaeus' (1758) description. As explained in Ganesh & Chandramouli (2011), Smith (1943), Daniel (2002), Whitaker & Captain (2004) and Goonawardene et al. (2006), correctly described *Lycodon aulicus* sensu stricto in their accounts of *Lycodon aulicus* although they did not recognize the two differ-





**Fig. 1.** *Lycodon aulicus* adult in life (a) from Sri Lanka, Photo: Dushantha Kandambi; (b) entire – dorsal view, dark morph; (c) entire – dorso-lateral view, light morph; (d) entire – dorsal view, (e) head – dorsal view, (f) head – lateral view, (g) mid-body profile view, all live adult specimens from Mayiladuthurai, India. Photos: S. R. Ganesh & S. R. Chandramouli (h) hemipenis of preserved specimen CAS (California Academy of Sciences) 215387 from Sagiang Divsn., Myanmar. Photo: Gernot Vogel.



**Table 1.** Geographical variation within the *Lycodon aulicus* and *L. anamallensis* groups. Min-max ranges and mean values (within parenthesis) are provided.

Characters	<i>Lycodon aulicus</i> s. str.			<i>Lycodon anamallensis</i>	
Regions (sample sizes of sexes)	Indoburma m=5, f=11	Peninsular India m=11, f=15	Sri Lanka m=9, f=6	Peninsular India m=3, f=5	Sri Lanka m=2, f=5
Ventrals (males)	182–205 (193.0)	180–206 (196.1)	180–186 (182.9)	174–186 (180.7)	184–186 (186.0)
Subcaudals (males)	68–72 (70.0)	65–74 (69.8)	61–70 (65.9)	63–64 (63.5)	71–73 (72.5)
Rel. tail length (males)	0.182–0.204 (0.195)	0.175–0.187 (0.183)	0.172–0.188 (0.181)	0.195–0.197 (0.196)	0.185–0.200 (0.192)
Ventrals (females)	186–207 (197.5)	191–215 (201.5)	190–202 (195.5)	186–197 (193.6)	195–204 (200.4)
Subcaudals (females)	56–74 (64.0)	57–73 (65.7)	57–67 (60.8)	60–74 (67.5)	63–71 (67.4)
Rel. tail length (females)	0.154–0.189 (0.175)	0.146–0.191 (0.167)	0.149–0.159 (0.155)	0.176–0.185 (0.181)	0.172–0.180 (0.175)

ent morphotypes. Goonawardene et al. (2006) also dealt with *L. osmanhilli*. Wall (1909) misunderstood Linnaeus' definition of this species and went on to name this same morphotype as his new subspecies *Lycodon aulicus oligozonatus* and remarked it to be rare in southern India. *Lycodon aulicus* is found throughout the Indian subcontinent including Nepal, Pakistan, Bhutan, Bangladesh, Myanmar, Sri Lanka and the mainland India (but not the Andaman and Nicobar Islands). It is also found in Mauritius and the Hawaiian Islands.

#### *Lycodon anamallensis* Günther, 1864

*Lycodon aulicus* 'typica' – Wall, 1909

*Ophites anamallensis* – Wall, 1923

*Lycodon osmanhilli* Taylor, 1950 **syn. nov.**

*Lycodon aulicus* (not of Linnaeus, 1758) –

Whitaker, 1978; Das, 2002; Das & De'Silva, 2005; Rao et al. (2005)

*Lycodon* cf. *aulicus* morph2 –

Ganesh & Chandramouli, 2011

*Lycodon aulicus* (in part.) Wallach et al. (2014)

**Material examined.** *Males* (*n*=5): **India:** BMNH 1904.10.18.2 Cannanore, Malabar, south India; BMNH 1904.10.18.4; Cannanore, Malabar, South India; CSPT/S-28b Madras, India; **Sri Lanka:** FMNH 25927 **Ceylon:** Colombo; MHNG 1198.70 Sri Lanka.

*Females* (*n*=10): **India:** BMNH 1946.1.14.92 Holotype of *Lycodon anamallensis* Anamallays; BMNH 1904.10.18.3 Cannanore, Malabar, Kerala; BMNH no number Madras; BMNH 1924.10.13.7 Mundakayan,

Trawancore, Kerala; CSPT/S-28a Madras; **Sri Lanka:** ZFMK 32253 Sri Lanka; UPZM-17a&b Peradeniya, Kandy; MHNG 744.7 Ceylon; NHMW 21689.4 Ceylon.

**Diagnosis (see also Taylor, 1950).** A species of *Lycodon* presently known from peninsular India and Sri Lanka, characterised by (1) a thin and small head, (2) absence of collar-mark on head; but the first 'band' passing across neck > 7–10 scales away from parietals, and converging towards tail, (3) a reddish-brown body with yellow or cream (never quite white) cross bars in life, (4) preocular usually not contacting frontal, (5) supraocular usually contacting prefrontal, (6) a shorter hemipenis with numerous long flounces and spines, (7) supralabials creamy with a median brown spot, usually 9 on each side, (8) bifid anal scales, (9) scale rows 17:17:15, (10) ventrals: 174–204 and subcaudals: 60–73 pairs, (11) relative tail length 0.14–0.20.

**Description and variation (Figs. 2–4).** A small to medium-sized (avg. 400 mm) snake with a thin head and neck, trunk and tail subcylindrical to slightly depressed. Rostral scale scarcely visible from above, nasals more or less pierced by nostril, partly sutured, in contact with 1<sup>st</sup> supralabial; internasals distinctly larger than nasals, in broad contact with preocular and loreal; loreal one on each side (two on each side in the nominotypical holotype); prefrontals longer than wide, each prefrontal as large as frontal, usually in contact with supraocular; anterior end of prefrontal distinctly half as wide as posterior end; frontal pentagonal, produced posteriorly, slightly larger than supraocular; anterior end of frontal distinctly





**Fig. 2.** Holotype of *Lycodon osmanhilli* KUMNH (Kansas University Museum of Natural History) 24141; (a) entire – dorsal view; (b) entire – ventral view; (c) jar label. Photos: Peter Uetz.

twice as wide as posterior end; frontal usually not in contact with preocular; parietals long, but distinctly smaller than its distance from internasals; postoculars 2; preocular 1, half as long as loreal; temporals usually 2+3+4; supralabials 9, 3<sup>rd</sup> to 5<sup>th</sup> contacting eye; infralabials usually 10–11, horizontally elongate, usually 1<sup>st</sup> to 5<sup>th</sup> touching anterior genials; anterior genials larger than posterior genials; prefrontals 1–3; ventrals 174–188 (avg. 186.0) in males and 186–204 (avg. 197.0) in females, angulate laterally; anal scale divided; subcaudals 63–73 pairs (avg. 67.8) in males and 60–72 pairs (avg. 66.6) in females; average of relative tail length 0.194 in males and 0.172 in females. Hemipenis short and stout, reaching only 7<sup>rd</sup>–8<sup>th</sup> subcaudal scale; mildly forked near tip; pedicel barely visible through elongate spines, hemipenial lobe head greatly broader than pedicel, unilobed, flattened, circular and disc-like; sulcal lips ornamented with heavy and elongate spines, many as long as two subcaudal scales; sulcus spermaticus duct barely visible on both sulcate and asulcate sides, being obscured by the spiny flounces. Sri Lankan specimens, in both the sexes have higher ventral and in males higher subcaudal scale counts than peninsular Indian specimens (see Table 1).

**Colouration in life.** Dorsum fawn brown or reddish-brown, never with a tinge of black; a series of about 15–32 yellowish-white or cream coloured cross bars, either wholly complete across the dorsum, or broad on the vertebral row and diverging or disintegrating into

two arms laterally, bands sometimes speckled inside with background colour; bands more thick and evident on forebody, obscure or absent on hindbody, rarely altogether absent; upper lip, lower lip, throat and chin pale pinkish white dotted with brown, venter uniformly white, pinkish-cream in juvenile specimens; tongue rosy pink; iris totally black, pupil mildly or not visible.

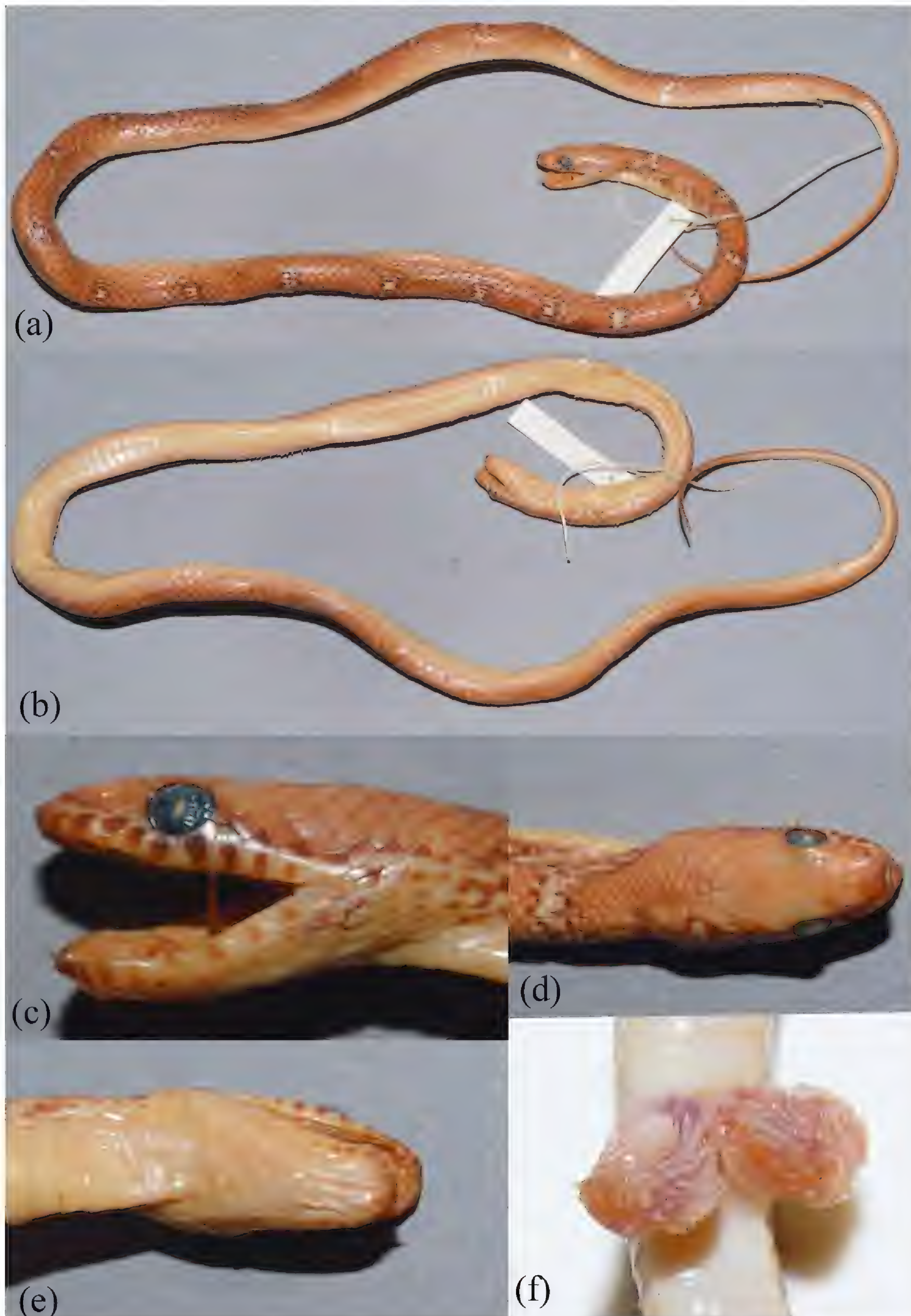
**Remarks.** Günther (1864) described *Lycodon anamallensis* based on a single specimen from the Anamallay Hills, Western Ghats, peninsular India, deposited in Col. R. H. Beddome's collection. Our re-examination of the holotype and additional preserved and living examples from India and Sri Lanka revealed that all specimens except the holotype have only one loreal scale on each side of head and divided anal scales. Therefore, we concur with Smith's (1943) remarks that the presence of double loreals on each side of head and undivided anal scale recorded in both Indian and Sri Lankan specimens are outliers and part of intraspecific variation (see also Wall, 1923). Taylor (1950) described *Lycodon osmanhilli*, discerning it from *L. aulicus* principally based on the character of the preocular separated from frontal. Our examination reveals that the holotype of *L. anamallensis* has its frontal separated from preocular on one side but contacting the preocular on the other side. However, our examination of both living and preserved specimens reveals that the holotype of *L. anamallensis* might be termed as a partial outlier in this character too. Nonetheless, preoc-





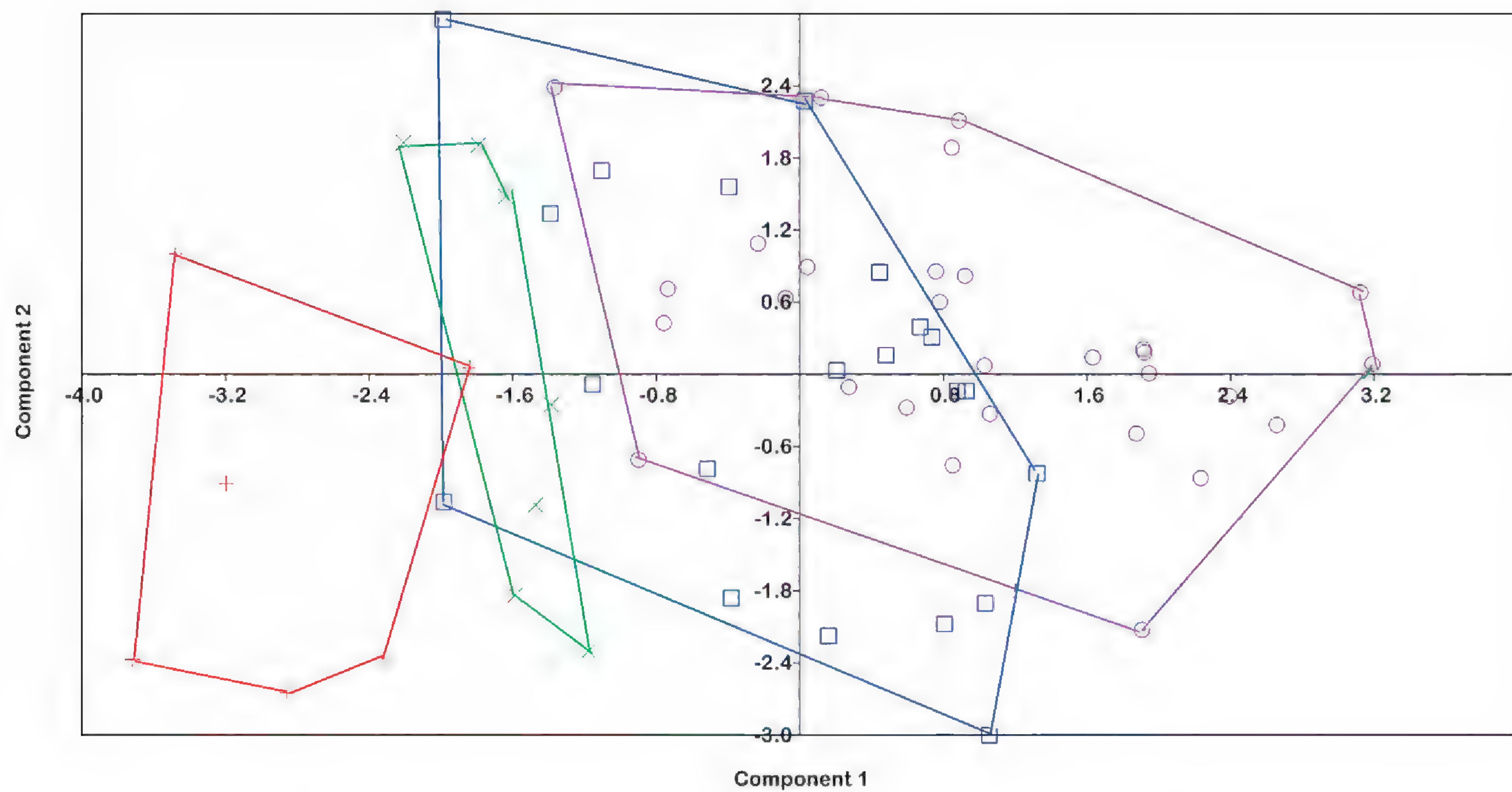
**Fig. 3.** *Lycodon anamallensis* in life (a) adult from Nuwalapitiya, Sri Lanka, Photo: Gernot Vogel; (b) adult from Madras, India; (c) adult, band-less morph from Mayiladuthurai, India; (d) adult with eggs; (e) a neonate from Madras; (f) head – lateral view; (g) head – dorsal view, of specimen from Mayiladuthurai, India. Photos: S. R. Ganesh & S. R. Chandramouli.



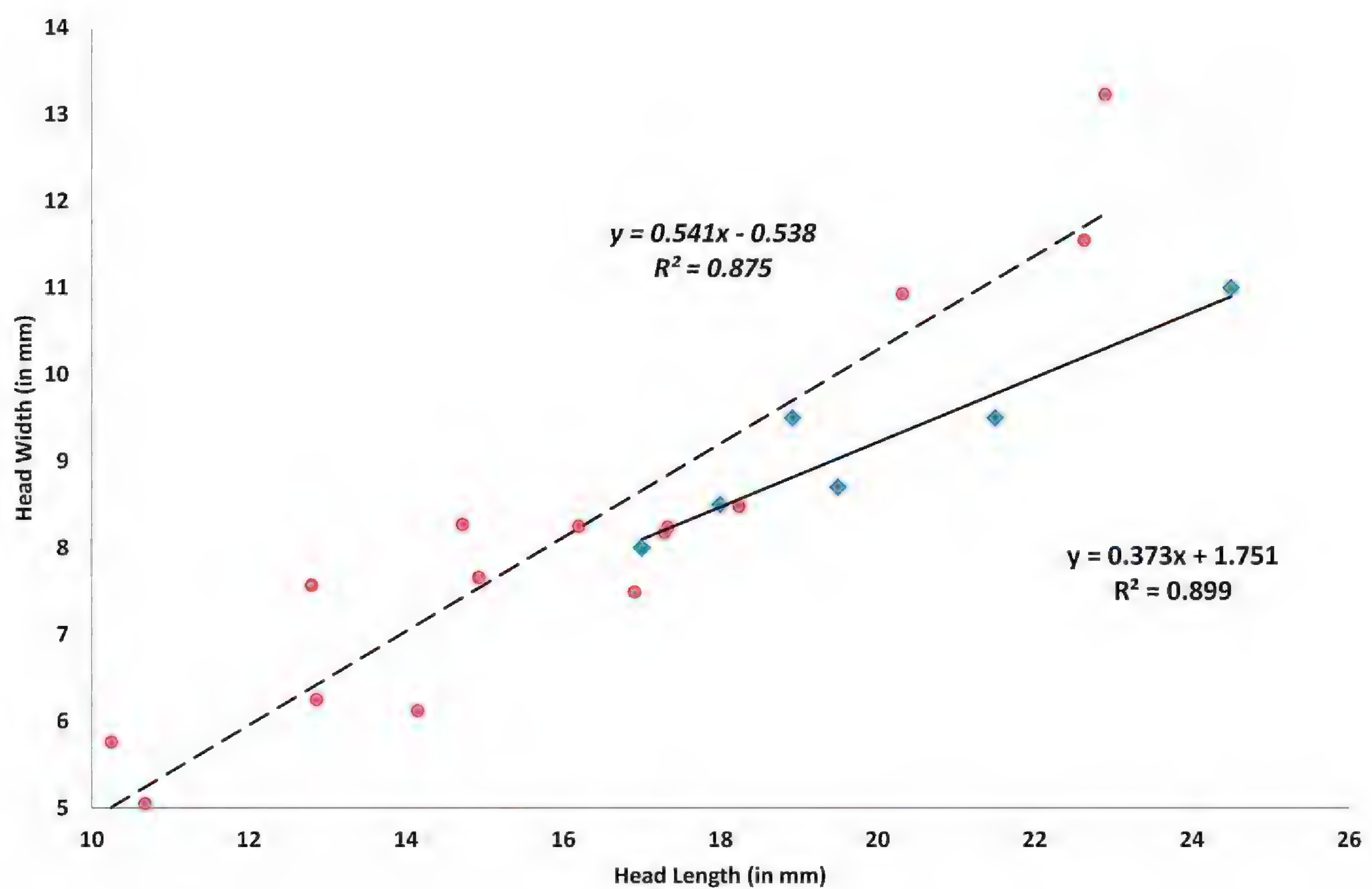


**Fig. 4.** *Lycopodon anamallensis* (a-e) Holotype, BMNH 1946.1.14.92, from Anamallays, India; (a) entire – dorsal; (b) entire – ventral; (c) head – lateral; (d) head – dorsal; (e) head – ventral views Photos: Gernot Vogel; (f) Non type CSPT/S-28a hemipenis of specimen from Madras, India Photo: S.R. Ganesh





**Fig. 5.** Principal Component Analysis plot showing rather mild separation of the taxa *L. anamallensis* (green cross – females, red plus – males) and *L. aulicus* (pink circles – females and blue squares – males).



**Fig. 6.** Regression biplot depicting differences in head length vs. head width ratios for *L. aulicus* s. str. (dotted line) and *L. anamallensis* (normal line).



**Table 2.** Comparison of diagnostic characters of peninsular Indian and Sri Lankan *Lycodon* species (except the strongly keeled-scaled *L. carinatus*, endemic to Sri Lanka). Data for other taxa sourced from Smith (1943), Whitaker & Captain (2004), and Mukherjee & Bhupathy (2007).

Characters	<i>Lycodon aulicus</i>	<i>L. anamallensis</i>	<i>L. striatus</i>	<i>L. flavicollis</i>	<i>L. flavomaculatus</i>	<i>L. travancoricus</i>
Collar	Present	Absent	Present	Present	Present (spot)	Obscure
Dorsal ground colour	Brown (rarely blackish)	brown	Blackish brown	Brown	Blackish brown	Blackish brown
Colour of bands	Creamy white	Yellowish white	White (with yellow mid-spot)	Yellow	Yellow	Yellow (rarely yellowish white)
Supralabials	9 (very rarely 8 or 10) <sup>1</sup>	9 <sup>2</sup>	8 (rarely 9)	9	9	9
Anal	2	2	2	2	2	1
Ventrals	180–215	174–204	154–166	210–224	165–183	176–206
Subcaudals	56–78	60–73	35–50	65–72	53–63	64–76
Hemipenis	Reaching 10 <sup>th</sup> subcaudal scale; not quite forked; smaller spiny flounces	Reaching 8 <sup>th</sup> subcaudal scale; mildly forked; broad spiny lobe head	Reaching 10 <sup>th</sup> subcaudal scale; mildly forked; distal 1/3 <sup>rd</sup> flounced, spinose at tip	Cylindrical, not forked at tip, lacks spines	Reaching 15 <sup>th</sup> subcaudal scale; forked at tip, mildly spinose	Reaching 12 <sup>th</sup> subcaudal scale; forked at tip; lobe head / pocket smooth
Distribution	Indian subcontinent	Peninsular India & Sri Lanka	Indian subcontinent	Western Ghats (low Nilgiris)	Northern Western Ghats	Hills of peninsular India

<sup>1</sup> 8 in 1 out of 120 cases, 10 in 3 out of 120 cases with two of these occurring on a specimen from Reunion

<sup>2</sup> In the holotype there are 10 supralabials on the left side, but it can easily be seen that one supralabial is split

ular-frontal separation is still a very typical character for *L. anamallensis* and is diagnostic when used in conjunction with other characters mentioned above.

As explained in Ganesh & Chandramouli (2011), the accounts of *Lycodon aulicus* sensu auctorum by Whitaker (1978), Das (2002), Das & De’Silva (2005) and Rao et al. (2005) refer to *Lycodon anamallensis*. Das & De Silva (2005) did so in their book covering Sri Lankan snakes, despite recognizing *L. osmanhilli*. Earlier, Wall (1909) had apparently mistaken the original concept of *L. aulicus* [s. str.] and after having discerned this *L. anamallensis* morphotype, called it *Lycodon aulicus typica* (contra Linnaeus, 1758) and remarked it to be quite common in southern India, commoner than *L. aulicus* as redefined herein. As currently understood, *L. anamallensis* is known to occur in peninsular India (roughly as far north as 21°N) and Sri Lanka. Based on our specimen examinations, *L. anamallensis* is absent in the Indian Ocean Islands like Mauritius, Reunion and the Hawaii.

Our Principal Component Analysis (Fig. 5) run based on 15 characters from 63 specimens, including 13 *L. anamallensis* specimens (7 m, 6 f) and 50 *L. aulicus* specimens (29 m, 21 f) revealed a mild separation of these forms with outliers, indicating their degree of crypsis to a certain extent. Of the 15 variables analysed, 7 had ei-

genvalues > 1, ranging from 1.03 in Component 7 to up to 2.61 in Component 1. They explained a variance of 99.18%. Component 1 was loaded on relative tail length, ventral and subcaudal scale counts, while Component 2 was loaded on head-scale configuration, collar and band patterns and supralabial markings. As can be seen by the PCA plot, *L. anamallensis* (green cross – females, red plus – males) and *L. aulicus* (pink circles – females and blue squares – males) appear fairly separated. There is a zone of overlap between the females of *L. anamallensis* and the males of *L. aulicus*. This explains the crypsis in this complex well. However, when analysed for head dimension, i.e., head length vs. head width ratio, there is a clear separation of these two taxa (Fig. 6). The regression analyses indicate substantial differences in head dimensions: for *L. aulicus* s. str.  $y = 0.541x - 0.538$   $R^2 = 0.875$ ; for *L. anamallensis*  $y = 0.759x - 4.645$   $R^2 = 0.933$ .

DISCUSSION

These two species, *L. aulicus* (Linnaeus, 1758) and *L. anamallensis* Günther, 1864, principally differ in head dimensions, collar and band patterns, sex-specific relative tail lengths, hemipenal morphology (see Tables 1, 2)



as well as in genetics (Pyron et al. 2013). These two species are largely sympatric over their geographic ranges in the Indian peninsula (Whitaker & Captain 2004; Das 2002; this work), leaving little doubt to their specific distinction.

Our examination of voucher specimens also revealed distinct and sometimes non-overlapping geographical variation in relative tail lengths, and ventral and subcaudal scale counts between populations within *L. aulicus* and *L. anamallensis* (see Table 1). However, it has to be noted that each of such geographically-concordant variant populations do fall within the corresponding morphotypes outlined above. Additionally, our material did not reveal these geographically-correlated clinal differences within populations of *L. aulicus* s. str. and *L. anamallensis* to be large enough to warrant any further splitting within these two species for the moment. Therefore, we for now refrain from naming each of these individual populations of *L. aulicus* from Nepal, Myanmar, peninsular India and Sri Lanka, and of *L. anamallensis* from peninsular India and Sri Lanka. We conservatively maintain this stance for future investigations.

Additionally, we think that the dilution of these clearly discernible morphotypes representing two distinct species under the name *L. aulicus*, mainly in the Indian peninsula, has caused confusion about the identification and distribution of this group of snakes. In Sri Lanka, however, the situation is different since the thin-headed form had been called as *L. osmanhilli* and was usually regarded as non-conspecific with *L. aulicus* (see Somaweera 2006). But recently Wallach et al. (2014) disregarded these variations and included *L. osmanhilli* in the synonymy of *L. aulicus* and worsened the situation. Pyron et al. (2013), in their genetic analysis, showed that *L. aulicus* and *L. osmanhilli* (i.e., from now on, a synonym of *L. anamallensis*) are not only genetically distinct, but actually belong to different clades, with *L. aulicus* clustering with *L. zawi* and *L. osmanhilli* clustering with the eastern species *L. capucinus*. As shown these two species are easily diagnosable by the characters mentioned above.

#### KEY TO SOUTH ASIAN LYCODON

- 1a. Body scales strongly keeled ..... *L. carinatus*
- 1b. Body scales not strongly keeled ..... 2
- 2a. Anal scale entire ..... *L. travancoricus*
- 2b. Anal scales divided ..... 3
- 2a. Ventrals < 200, body more black than brown ..... 4
- 3b. Ventrals > 200, body more brown than black ..... 5
- 4a. Usually 8 supralabials, reticulations white or with yellow mid-spots ..... *L. striatus*
- 4b. Usually 9 supralabials, reticulations always yellow ..... *L. flavomaculatus*
- 5a. Yellow collar always present, no other pattern, ventrals not angulate laterally ..... *L. flavicollis*

- 5b. Collar present or absent, body uniform or banded, ventrals angulate laterally ..... 6
- 6a. Collar present, touching the parietals, converging towards snout tip ..... *L. aulicus*
- 6b. Collar absent, first band far away from parietals, converging towards tail ..... *L. anamallensis*

**Acknowledgments.** We are grateful to our respective organisations for supporting our research activities. At the Chennai Snake Park, thanks are due to Executive Chairman and Trustees. We thank the following persons, who gave us access to specimens in their care: Patrick Campbell (BMNH); Jens Vindum and Alan Leviton (CAS), Alan Resetar and Harold Voris (FMNH), Heinz Grillitsch, Silke Schweiger and Georg Gassner (NHMW), Andreas Schmitz (NHMG), Gunther Köhler and Linda Acker (SMF), Rupika Rajakaruna, Madhava Meegaskumbura (UPZM), Dennis Rödder and Wolfgang Böhme (ZFMK), Mark-Oliver Rödel and Frank Tillack (ZMB). We are thankful to Peter Uetz and Dushantha Kandanmby for providing photographs, S.R. Chandramouli for providing pictures and for advising on statistics and Johan Van Rooijen for advising on statistics. We thank Ruchira Somaweera for providing information on Sri Lankan snakes and Sameera Suranjan Karunaratna for his information on Sri Lankan fauna and for all his help during our Sri Lankan visits. Also a big thank you for Madhava Botejue, Dushantha Kandanmby, Udaya Chanaka (the Joga master) and Thasun Amarasinghe for their help during the field trips. Finally, we would like to thank Patrick David and Nis Nicolaisen for reviewing the manuscript.

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# *Epiplatys bifasciatus* (Steindachner, 1881) (Nothobranchiidae) and *Hemichromis fasciatus* Peters, 1852 (Cichlidae), two relict fish species in the Sahara desert

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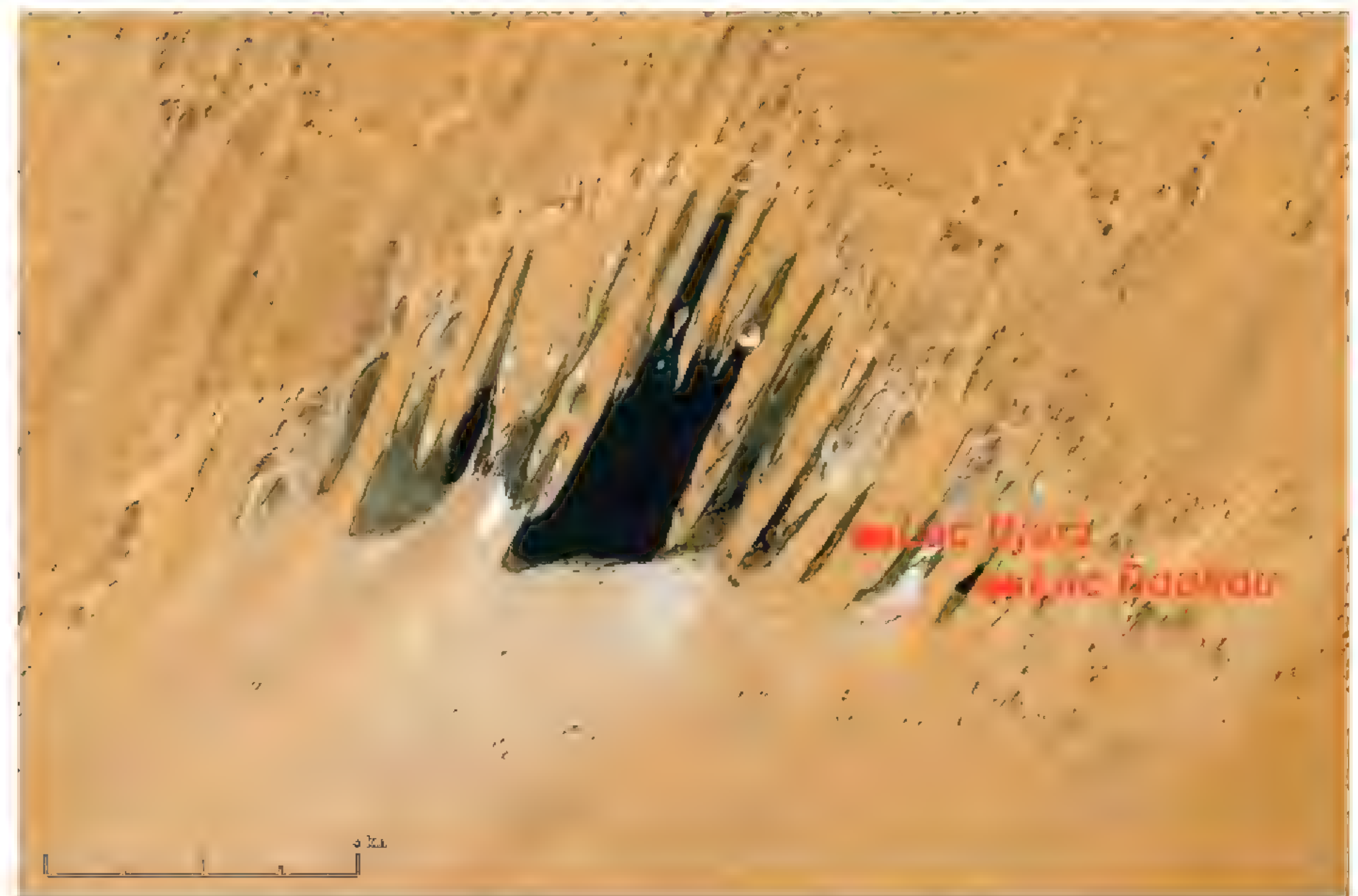
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**Abstract.** Two tropical fish species, *Epiplatys bifasciatus* and *Hemichromis fasciatus*, are recorded for the first time from the Sahara desert, in Lake Boukou and Lake Djara respectively, two of the seven Ounianga Serir lakes in northern Chad. The nearest known populations of these two species are located 900 km to the southwest in Lake Chad. The Ounianga Serir lakes, which resisted the increasing aridity of Sahara since the Holocene by virtue of subsurface inflow of fresh groundwater from a large fossil aquifer, present the richest relict fish fauna of the Sahara, with at least eight species, including also *Hemichromis* cf. *letourneuxi*, *Sarotherodon galilaeus borkuanus*, *Coptodon zillii*, *Astatotilapia tchadensis*, *Polypterus senegalus* and *Poropanchax normani*.

**Key words.** Biogeography, relict fish hotspot, climate change, killifish, cichlids, Ounianga, Chad.

## INTRODUCTION

Relict fish populations are known in several perennial bodies of waters of the Sahara desert, most of them located in mountainous massifs of central Sahara: the Adrar mountains in Mauritania, the Ahaggar, Tassili n'Ajjer and Mouydir in Algeria, and the Tibesti and Ennedi in Chad (Lévêque 1990, 2006; Trape 2009). Fish diversity is low, only two dozen of species have been recorded for the whole Sahara, and most species are known from a very low number of permanent water bodies, often from a single spring, guelta, pound or lake (Trape 2009). The number of species sharing the same water body usually ranges from one to three, with a maximum of four species



**Fig. 2.** Satellite view of Ounianga Serir lakes, with location of Lake Djara and Lake Boukou.



**Fig. 1.** Satellite view of the Sahara with location of Ounianga lakes (Chad).

in Molomhar guelta in Mauritania, and seven species in Totous guelta in Tibesti in Chad (Daget 1959, Lévêque 1990, Monod 1951, Trape 2009).

During zoological surveys in northern Chad in 2013 and 2014, fishes, reptiles, amphibians, and invertebrates were collected in various areas of Borkou, Ennedi and Tibesti (Brancelj 2015, Dumont 2014, Trape 2013, 2015, 2016). Among fishes collected in Ounianga Serir Lakes in 2013 and 2014 (Figs 1–2), several specimens belonged to three species never reported before from northern Chad nor from other areas of the Sahara desert, namely *Poropanchax normani* (Ahl, 1928) (Poeciliidae), *Polypterus senegalus* Cuvier, 1829 (Polypteridae), and the previ-



ously undescribed *Astatotilapia tchadensis* Trape, 2016 (Cichlidae) (Trape 2013, 2016). Other species reported from Ounianga Serir lakes included *Sarotherodon galilaeus borkuanus* (Pellegrin, 1919), *Hemichromis* cf. *letourneuxi* Sauvage, 1880 (erroneously reported as *Hemichromis bimaculatus* Gill, 1862), and *Coptodon zillii* (Gervais, 1848) (Daget 1959, Lévêque 1990, Trape 2013). Here I report the occurrence of two additional species collected in these lakes in 2016, both representing remarkable additions to the known relict fish fauna of the Sahara.

## MATERIAL & METHODS

Measurements, counts and diagnosis were made as described in Paugy et al. (2003), Wildekamp & Van der Zee (2003) and Teugels & Thys Van den Audenaerde (2003). Measurements were made with a digital calliper, and counts partly under a dissecting microscope. Species keys of Teugels & Thys Van den Audenaerde (2003) and Wildekamp & Van der Zee (2003) were used for the species diagnosis of *Hemichromis fasciatus* and *Epiplatys bifasciatus*, respectively. Preserved specimens are deposited in the Museum national d'Histoire naturelle (MNHN) at Paris.

## RESULTS

### *Hemichromis fasciatus* Peters, 1852 (Fig. 3)

**Material examined.** MNHN 2016.0272, previously IRD TR.4515, collected in Lake Boukou (18°54'54"N, 20°54'40"E, elev. 363 m) (Fig. 4) on April 4<sup>th</sup> 2016 in the evening using a fishing rod by Jacques Robin.

**Description.** Two lateral lines. Scales cycloid. No pharyngeal hanging pad between gills. Outer jaw teeth



**Fig. 3.** *Hemichromis fasciatus* from Lake Boukou in life.



**Fig. 4.** View of Lake Boukou.

monocuspid. Upper profile of snout concave. Premaxilla extremely protrusible. Lower jaw distinctly prominent. Dorsal fin with 14 spines and 12 soft rays. Anal fin with 3 spines and 9 soft rays. Number of lateral-line scales: 29. Five dark blotches on sides, the first blotch confluent with the opercular spot, the fifth on caudal-fin base. Standard length 180 mm.

### *Epiplatys bifasciatus* (Steindachner, 1881) (Fig. 5)

**Material examined.** MNHN 2016.0273, 5 specimens collected in Lake Djara (18°55'09"N, 20°53'39"E, elev. 355 m) (Fig. 6) on April 9<sup>th</sup> 2016 by Jean-François Trape. Specimens were collected at night on the shore of the lake using a dipnet.



**Fig. 5.** Two specimens of *Epiplatys bifasciatus* from Lake Djara in life.





**Fig. 6.** View of Lake Djara.

**Description.** A tubular pre-ocular system with five pores. A frontal supra-orbital neuromast system consisting of one pit with two neuromasts. Dorsal fin 8–9 rays, anal fin 14–18 rays. Scales on mid-lateral series 26–27. Life colours of males (Fig. 5) are typical of this species (see Wildekamp & Van der Zee 2003) with in particular oblique red stripes on the opercle, a large number of oblique red bars on the sides and the back, a wide dark grey longitudinal band extending from the opercle to the caudal peduncle, and a number of red spots on the anal, dorsal and caudal fins. Standard length 37–39 mm.

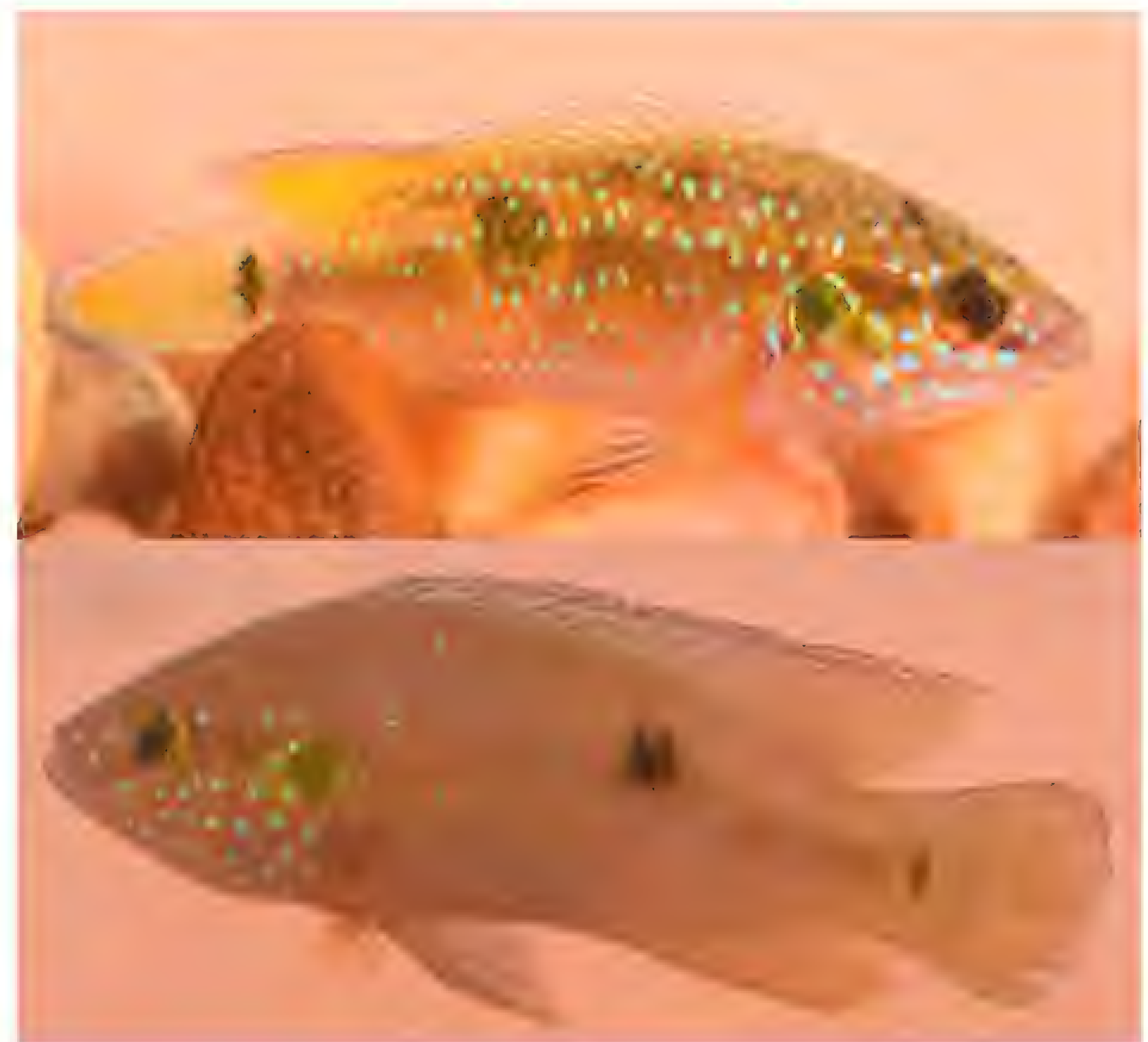
## DISCUSSION

*Hemichromis fasciatus* is a well-known afrotropical cichlid, abundant and widespread in most hydrographic basins of West and Central Africa, in particular in Lake Chad and the Senegal and Niger rivers basins (Lévêque et al. 1991; Teugels & Thys van den Audenaerde 2003). *Hemichromis fasciatus* has never been reported before in the Sahara, contrary to its widespread congener *Hemichromis bimaculatus*, a complex of species with unresolved taxonomy which is probably represented by *H. letourneuxi* in Ounianga Serir, Ounianga Kebir, and some other bodies of water in the Sahara (Fig. 7) (Lévêque 1990, Lévêque et al. 1991, Loisele 1979, Sauvage 1880, Trape 2013, Teugels & Van den Audenaerde 2003).

*Epiplatys bifasciatus* is a killifish with a large distribution from Senegal in West Africa to Sudan in East Africa, both in weedy parts of rivers, swamps, small brooks and rivulets in the Guinean and Sudanese savanna, and in coastal lagoons on the shore of the Atlantic Ocean (Wildekamp & Van der Zee 2003). The two other known populations of killifish that survived the increasing aridity of the Sahara since the Holocene are both located in northern Chad in a single body of water: *Epiplatys spilar-*

*gyreus* (Duméril, 1861) in Tigui pool (Borkou) (Estève 1952, Lévêque 1990), and *Poropanchax normani* in Lake Boukou (Trape 2013). The nearest current populations of these three species are located 900 km to the southwest in Lake Chad (Blache 1964).

According to Grenier et al. (2009) the Ounianga Serir lakes were connected to Megalake Chad in the Holocene. Despite the current extreme aridity in this area – average annual rainfall is less than 5 mm and annual evaporation exceeds 6000 mm – these lakes persist by virtue of sub-surface inflow of fresh groundwater from a large fossil aquifer (Kröpelin 2007). The remarkable biodiversity of these lakes has remained poorly investigated and until recently only the two fish species collected during the Thilo expedition (1912–1917) in northern Chad – *Sarotherodon galilaleus borkuanus* and *Hemichromis* cf. *letourneuxi* – were known from Ounianga Serir lakes (Pellegrin 1919). In fact, with at least eight species, these lakes present the richest fish fauna of the Sahara desert.



**Fig. 7.** *Hemichromis* cf. *letourneuxi* from Lake Djara (top) and Ounianga Kebir (bottom) in life.

**Acknowledgements.** I thank Jacques Robin and Jean-François Trape who collected these interesting specimens.

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## News from the Balkan refugium: Thrace has an endemic mole species (Mammalia: Talpidae)

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**Abstract.** We utilized 1084 bp sequences of the cytochrome *b* gene to assess the taxonomic status of small blind moles from eastern Thrace in Bulgaria and European Turkey. So far, these moles were classified either as *Talpa caeca* or as *T. levantis*. Our study showed them to be genetically closer to *T. europaea*, *T. aquitania*, and *T. occidentalis*, albeit not being part of any of these species. We describe them as a new species, *Talpa martinorum* n. sp. The new species differs from *T. europaea*, another mole occupying Thrace, by having a sealed palpebral fissure and a 1<sup>st</sup> upper molar with no parastyle, and by being smaller. The contemporary distribution range of *T. martinorum* n. sp. is small and restricted to the Black Sea coast between Burgas (Bulgaria) and Istanbul (Turkey). The species name is an eponym to the married couple Vladimir and Evgeniya Martino, two early students of Balkan mammals.

**Key words.** Balkans, cytochrome *b*, cryptic species, species delimitation, *Talpa martinorum* n. sp.

### INTRODUCTION

Moles (family Talpidae, Lipotyphla) are widespread in temperate Eurasia, North America, and in Oriental Southeast Asia. The majority of species has adapted to a subterranean mode of life and displays convergent morphologies. Interspecific differences are usually slight and further obscured by morphologic plasticity. The traditional approach towards mole taxonomy, based solely on cranial and dental traits, frustrated early students and posed a long-lasting source of dispute and disagreement over a number of genera and species. Since 1758, when Linnaeus named the first mole species (Linnaeus 1758), about 180 species group names accumulated (Hutterer 2005) for over 50 currently valid species. In the past, the authors disagreed which of these names were valid and which were to be considered of subspecific value or just synonyms. For example, Schwarz (1948) synonymized five currently valid generic names from Asia with *Talpa*, and reduced the number of Eurasian fossorial moles to merely six species; Ellerman & Morrison-Scott (1951) further condensed these to four species in two genera.

Despite obvious taxonomic problems with moles, molecular tools were employed in talpid systematics relatively late (Colangelo et al. 2010; Bannikova et al. 2015; Feuda et al. 2015; He et al. 2016). It became immediately clear how incomplete our alpha taxonomic knowledge of the Eurasian moles was. He et al. (2016) proposed that talpid species richness is underestimated by nearly one third. Although the majority of these undescribed species occupy mountain areas in southern China, several cryp-

tic species were recently found also in the genus *Talpa* in Europe (Nicolas et al. 2017a) and south-western Asia (Bannikova et al. 2015).

In this paper we utilized molecular evidence in assessing the taxonomic status of small blind moles along the south-western Black Sea coast, specifically in Thrace of Bulgaria and European Turkey. Osborn (1964) was the first to realize that the region features two distinct mole species, a larger *T. europaea*, which is widespread in Europe, and a smaller one, which he took for *T. caeca*. In Osborn's times, *T. caeca* contained small blind moles of southern Europe, northern Anatolia, and the Caucasus (Ellerman & Morrison-Scott 1951, Grulich 1972), which are currently classified as distinct species (*T. davidiana*, *T. levantis*, *T. occidentalis*; Hutterer 2005). Doğramacı (1988, 1989c) applied the epithet *levantis* (*T. caeca levantis*) for small moles of Thrace and northern Anatolia. Following Pavlinov & Rossolimo (1987), Vohralík (1991) and Kefelioğlu & Gençoğlu (1996) accepted *T. levantis* as a species on its own right specifically for the European populations. As a result, four mole species are reported for south-east Europe (the Balkan Peninsula): *T. europaea* in the north and east, *T. caeca* and *T. stankovici* in the south-west, and *T. levantis* in the south-east (Hutterer 2005).

### MATERIAL AND METHODS

**Specimens.** We studied 14 individuals of *T. martinorum* n. sp. (see below) and comparative material of 244



museum vouchers belonging to 11 species of *Talpa* (Appendix 1). Individuals of *T. martinorum* n. sp. were collected in Bulgaria in 2011 (one individual) and 2017 (the remaining 13). External measurements were scored before skinning to the nearest 0.1 mm (hind foot) or 1 mm (the rest): length of head and body (from snout tip to anus), length of tail (from anus to tail tip with exclusion of terminal hairs) and length of hind foot (without claws). Body mass was recorded to the nearest 0.5 grams. We examined the palpebral fissure using a 10x magnifying glass and photographed each mole captured in 2017. In part the individuals were immersed in ethanol and the rest were processed following standard mammalogical procedures (Kryštufek & Vohralík 2001). Skins were mounted on cardboard (carded skins) while skulls and postcranial skeletons were preserved in 95% ethanol, dried subsequently and cleaned by *Dermestes* beetles. Tissue samples for DNA analysis were placed in non-denaturated 96% ethanol and subsequently refrigerated. All field procedures involving handling of animals in this study were in compliance with guidelines approved by the American Society of Mammalogists (Sikes et al. 2011).

**Molecular analysis.** The cytochrome *b* (Cyt *b*) gene was sequenced for eight specimens of the new species. These sequences were analyzed together with 23 additional *Talpa* sequences (within 13 species), and three outgroup Talpinae sequences (*Urotrichus talpoides*, *Euroscaptor parvidens* and *Euroscaptor klossi*), all downloaded from GenBank. Collecting data for the new sequences and all GenBank numbers are given in Appendix 2.

For the new specimens, total genomic DNA was extracted from ethanol-preserved muscle tissue using silica membrane columns of the Blood and Tissue kit by Qiagen (Hilden, Germany). DNA extracts are available from the ZFMK Biobank, Bonn (DNA voucher IDs are listed in Appendix 2). For PCR amplifications, we used the Qiagen Multiplex PCR kit, following the manufacturer's specifications and based on 2 µl undiluted DNA template in 20 µl total reaction volumes. DNA fragments of 1084 bp were amplified with an Applied Biosystems GeneAmp PCR System 2700 (Life Technologies), applying the primers L14724ag (5'-ATGATATGAAAAC-CATCGTTG-3') and H15915ag (5'-TTTCCNTTTCTG-GTTTACAAGAC-3') (Guillén-Servent & Francis 2006). PCR routine followed a 'touch-down' protocol: Taq activation: 15 min at 95°C; first cycle set (15 repeats): 35 s denaturation at 94°C, 90 s annealing at 60°C (−1°C per cycle) and 90 s extension at 72°C. Second cycle set (25 repeats): 35 s denaturation at 94°C, 90 s annealing at 50°C, and 90 s extension at 72°C.

After enzymatic cleanup, all PCR products were Sanger-sequenced at Macrogen Europe's commercial Sanger sequencing service (Amsterdam, NL). Sequences were assembled, inspected and aligned using Geneious vers. R7 (Biomatters, Auckland, New Zealand).

The Maximum Likelihood (ML) tree was inferred with RAxML-HPC vers. 8.1.24 (Stamatakis 2014). For the ML search, a GTR+Γ model of sequence evolution was applied following the program recommendations. The dataset was partitioned to treat 3rd codon positions separately from 1<sup>st</sup> and 2<sup>nd</sup> positions. The analysis used the “-f a” option (bootstrap analysis and search for best-scoring ML tree in one program run) and included 100,000 bootstrap replicates. Nodes with a bootstrap support of 50 or below were collapsed. To comparatively assess the topology delivered by the ML reconstruction, a Bayesian analysis was run for 5 million generations (assuming a GTR+Γ model and unlinking 3<sup>rd</sup> positions) in MrBayes vers. 3.2 (Ronquist & Huelsenbeck 2003), but results were very similar and hence not shown in a separate illustration.

**Morphological analysis.** Our study was based on visual examination of museum specimens, both macroscopically and under a stereomicroscope at different magnifications. Museum vouchers (skins, skulls and occasionally postcranial skeletons) are deposited in the following collections (acronym in parentheses): Field Museum of Natural History, Chicago (FMNH), National Museum of Bosnia and Herzegovina, Sarajevo (ZMBiH), National Museum of Natural History, Washington D. C. (NMNH), National Museum of Natural History Sofia (NMNHS), Natural History Museum London (NHML), Naturhistorisches Museum Wien, Vienna (NMW), Museum Nationale d'Histoire Naturelle, Paris (MNHN), Mammal Collection in the Ondokuz Mayıs University, Samsun, Turkey (OMU), Slovenian Museum of Natural History, Ljubljana (PMS), Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK), and Zoological Institute and Zoological Museum, Russian Academy of Sciences, St. Petersburg (ZIN). Vouchers in ZFMK and PMS were directly compared to *T. martinorum* n. sp.. Material from the remaining collections was examined by BK prior to this study and records were compiled to contain measurement data, drawings and photographs.

Skull morphology was quantified using a set of six cranial variables which were scored using a Vernier caliper with accuracy to the nearest 0.1 mm (acronyms in parentheses): condylobasal length of skull (CbL), length of maxillary tooth row (MxT; canine to 3<sup>rd</sup> molar), breadth of braincase (BcB), height of braincase (BcH; bullae excluded), breadth of rostrum over canines (RoC), and breadth of rostrum over molars (RoM). We also measured the pelvis (greatest length and greatest anterior breadth) and the humerus (length and width). Length and width of 3<sup>rd</sup> upper molar were scored under a dissecting microscope fitted with an eyepiece graticule. Three morphotypes of the pelvis (sensu Grulich 1971, Popov & Miltchev 2001) were distinguished: (i) the caecoid morphotype lacked a bony anastomosis between the *os sacrum* and the *os ischii* posterior to the 4<sup>th</sup> *foramen sacrale*; (ii) the europaeoid morphotype had a well-developed and



ossified anastomosis and a closed 4<sup>th</sup> *foramen sacrale*; (iii) in the intermediate morphotype, the foramen was closed, the anastomosis, however, was thin and narrow, and the ischio-sacrale suture was not ossified.

Heterogeneity between samples was assessed in one-way analysis of variance (Anova). To characterize the craniometric variation among species of moles and to find patterns in our high-dimensional data, we used principal components analysis (PCA), which was performed on the correlation matrix of  $\log_{10}$ -transformed cranial variables. The resulting principal components (PCs) are linearly uncorrelated; therefore, each PC measures different ‘dimensions’ of the original dataset. The first PC (PC1) is responsible for the largest possible variance and acts in morphometrics as a size vector (Kryštufek et al. 2015). Rates of correct classification of *a priori* defined species were evaluated by discriminant analysis (DA). To evaluate the performance of the DA and avoid the risk of overfitting the data, all analyses were cross-validated using the jackknife procedure, in which each specimen is classified into a group using the discriminant function derived from all specimens except the specimen being classified. Statistical tests were run in Statistica 7.0 (StatSoft Inc., OK, USA) and SPSS Statistics 2012 (IBM Analytics, NY).

## RESULTS

**Molecular results.** Sequencing of the eight samples resulted in a single haplotype, with the exception of one alignment position (pos. 215) with ambiguous information (‘N’) in 3 sequences. No stop-codon insertions or deletions were observed in the alignment.

In the ML tree, our new samples of *T. martinorum* n. sp. clustered with *T. europaea*, *T. aquitania*, and *T. occidentalis* into a weakly supported clade (Fig. 1). The Bayesian analysis includes also *T. romana* and *T. caeca* in this cluster. Above species level, the ML branching pattern was poorly supported (the very similar topology in MrBayes had higher support values – but see Douady et al. (2003), among others, on potentially misleading high posterior probability values). Therefore the tree topology offers only a meagre idea on phylogenetic relationships among species. At species level however, support values are usually much higher: the new species *T. martinorum* is recovered as monophyletic with maximal bootstrap support. Also the genetic metrics show that *T. martinorum* n. sp. is clearly separated from all other moles: the closest genetic matches to *T. martinorum* n. sp. were *T. europaea* and *T. occidentalis* with *p*-distances of more than 9% (i.e., distances well above the typical intraspecific range, see below). Maximal interspecific distances for *T. martinorum* n. sp. were registered towards *T. altaica* and *T. talyschensis* (both ca. 14%). Minimal interspecific distances among all *Talpa* species in the dataset were ca.

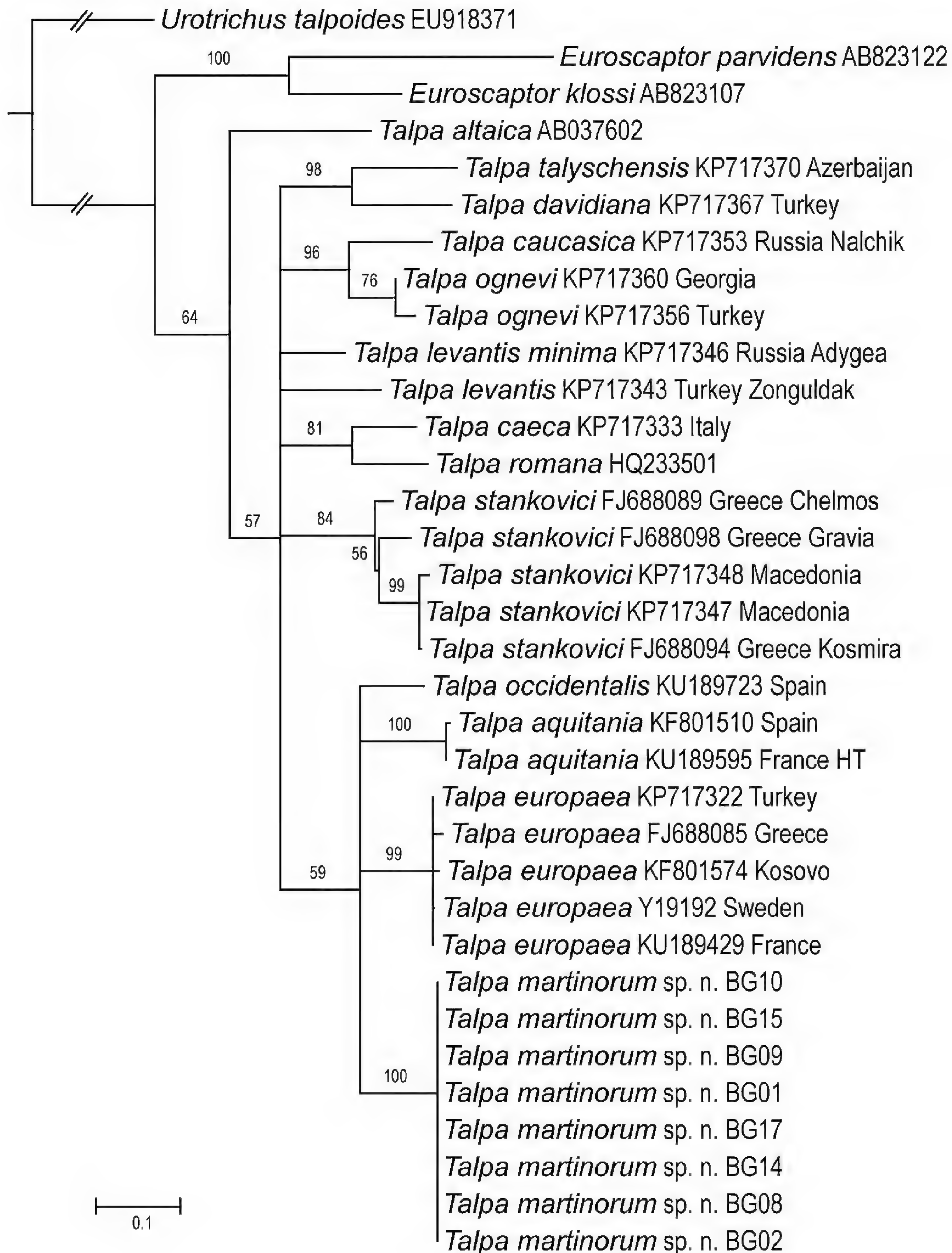
8%, maximal distances 15%. Intraspecific *p*-distances in *T. martinorum* n. sp. were 0.0 to 0.1% (the 0.1% divergence created through the position mentioned above), 0.4 to 1.9% in *T. europaea*, 2.6% in *T. aquitania*, 1.8% in *T. ognevi*, and 0.4 to 6.9% in *T. stankovici*. Conspicuously high distances within *T. stankovici* result from the inclusion of genetically highly divergent Greek populations (from Gravia and Chelmos; see Tryfonopoulos et al. 2010). The two specimens representing the two subspecies of *T. levantis* (i.e., *T. levantis levantis* and *T. levantis minima*) were separated by a distance of 7.5%.

**Morphometric results.** Secondary sexual dimorphism in size (SSD) is usually obvious in the genus *Talpa* (Niethammer & Krapp 1990). Our sample from Thrace contained nine males and four females, of which nine were clean skulls. We therefore tested SSD only on the external measurements. One-way analysis of variance detected significant heterogeneity between sexes only in length of hind foot ( $F=9.45$ ,  $p=0.012$ ) with males attaining a higher mean ( $17.21\pm0.204$  mm) than females ( $16.13\pm0.289$  mm). Since the remaining external traits showed no significant SSD ( $F<2.8$ ,  $p>0.12$ ), we pooled the sexes.

All cranial measurements retrieved highly significant interspecific heterogeneity ( $F>18$ ,  $p<0.001$ ) with highest *F*-values ( $F>30$ ) for length of skull and breadth of rostrum. To visualize morphometric distances and similarity between species we ran PCA on 187 complete skulls belonging to 11 species. *Talpa caucasica* was excluded because the available skulls were damaged. The first two principal components (PC1 and PC2) in concert explained 87.7% of the variance in the original data set and were used to display morphometric relationships between species (Fig. 2). PC1 had high positive loadings for all measurements and sorted moles according to their overall size, from the smallest (negative scores on the left hand side of the PC1 axis) to the largest (positive scores on the right hand side of the axis). PC2 arranged moles in respect to breadth of rostrum over molars. Moles with high PC2 loadings had a broad rostrum and vice versa. There was considerable overlap in the centre of the plot between *T. martinorum* n. sp., *T. levantis*, *T. talyschensis*, *T. occidentalis*, and the larger individuals of *T. caeca*. *Talpa europaea* was well characterized by a combination of large skull size and relatively narrow rostrum; *T. aquitania* was less variable than *T. europaea* and on average had a narrower rostrum. The rostrum was most robust in *T. stankovici* and *T. davidiana*; *T. romana* was transitional in this respect towards *T. europaea*. *Talpa caeca* attained smaller dimensions than any other mole in our analysis. Noteworthy, all principal components showed significant heterogeneity between species ( $F>2.5$ ,  $p<0.072$ ).

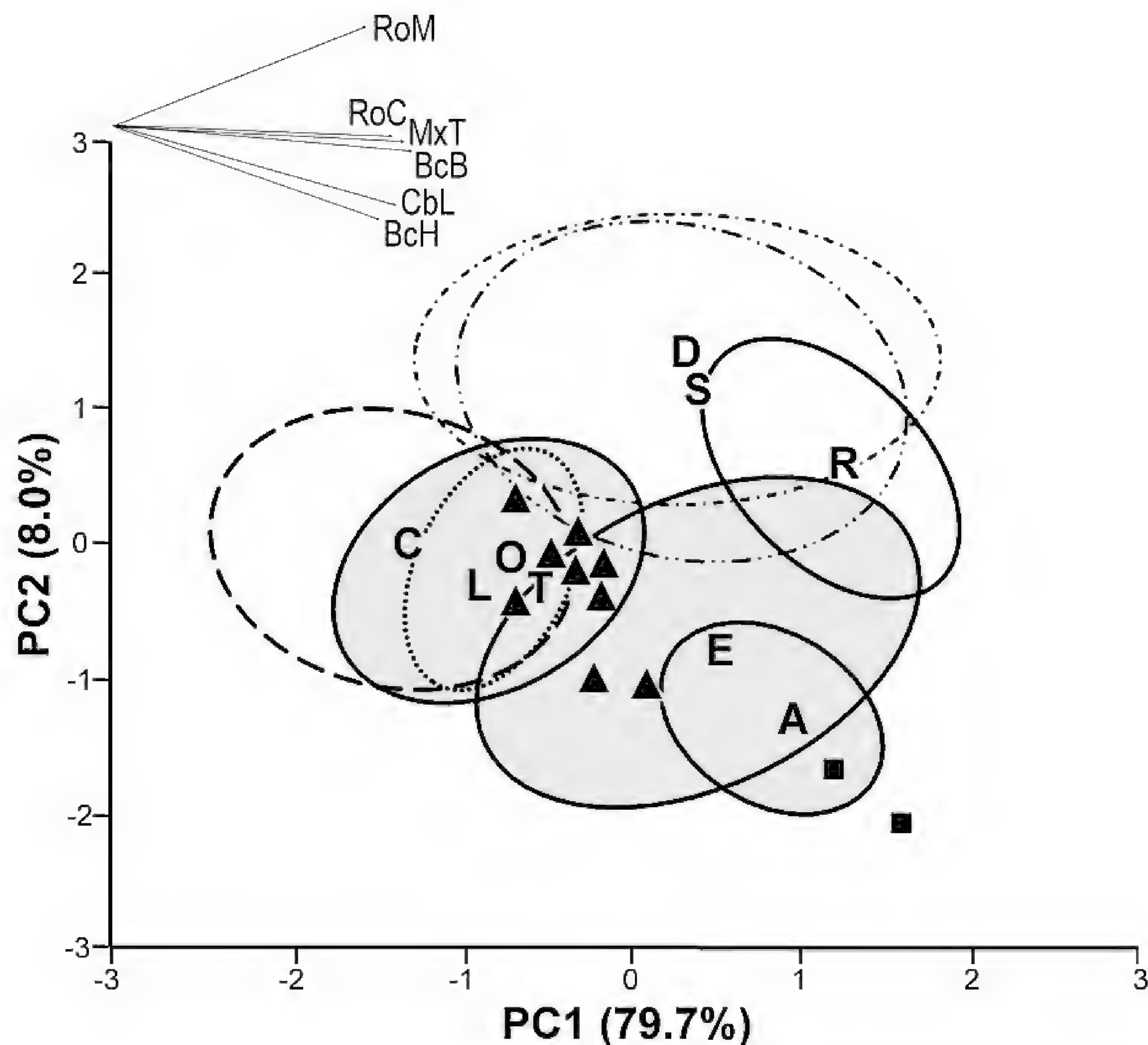
Discriminant analysis performed on the same matrix of  $\log_{10}$ -transformed cranial variables (Wilks’  $\lambda = 0.0248$ ,  $F = 14.408$ ,  $p<0.0001$ ) classified 65.6% (cross-validated 56.8%) of specimens to the correct species. All pair-





**Fig. 1.** Maximum likelihood tree inferred from 1084 bp of the mitochondrial cytochrome *b* gene for 14 species of the genus *Talpa*. Bootstrap values are shown on the nodes. The tree is rooted with *Urotrichus talpoides*, *Euroscaptor parvidens* and *Euroscaptor klossi*.





**Fig. 2.** Projection of group centroids (upper case letters) onto the two principal components (PCs) resulting from principal components analysis of six  $\log_{10}$ -transformed cranial variables (percentage of variance explained by each component is in parentheses) of 10 *Talpa* species. Ellipses are 95% confidence limits of the dispersion in each species except *T. martinorum* n. sp. (specimens shown by triangles), *T. altaica* (squares) and *T. talyschensis* (only group centroid is shown). Area inside the ellipses for *T. aquitania*, *T. europaea* and *T. occidentalis* are shaded grey. The character vector diagram illustrates the relative contribution of the original variables (see text for acronyms) to the principal components. Abbreviations for centroids: A – *T. aquitania*, C – *T. caeca*, D – *T. davidiana*, E – *T. europaea*, L – *T. levantis*, O – *T. occidentalis*, R – *T. romana*, S – *T. stankovici*.

wise-squared Mahalanobis distances ( $D^2$ ) were significant except two (*T. talyschensis* against *T. occidentalis* and *T. martinorum* n. sp., respectively). Pairwise  $D^2$  distances with *T. martinorum* n. sp. (mean  $\pm$  standard error =  $10.72 \pm 5.56$ ) were low in comparison to the remaining pairwise distances ( $20.21.87 \pm 2.62$ ), the difference however was not significant ( $F=3.28$ ,  $p=0.076$ ).

#### A new mole species from Thrace

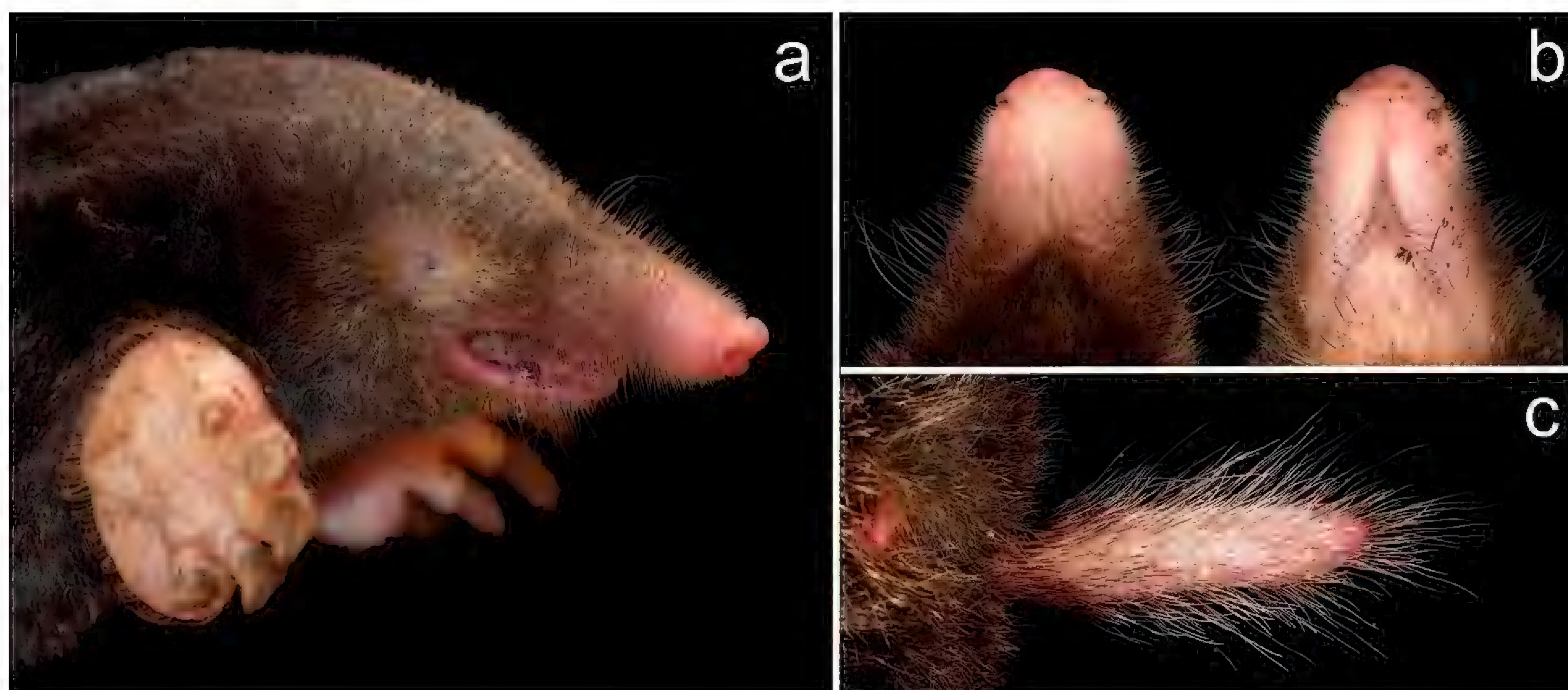
*Talpa martinorum* n. sp. (Figs. 3, 4, 5a, 6a)

**Holotype and type locality.** Skin mounted on cardboard, skull, postcranial skeleton, and tissue sample in ethanol of a young adult female (ZFMK-MAM-2017.1149; tis-

sue: ZFMK-TIS-23035), collected by B. Kryštufek and N. Nedyalkov on 27.04.2017 (field No. BG8) on the edge of a meadow near Zvezdets, Mt. Strandzha, Bulgaria. DNA of this specimen has been deposited (ZFMK-DNA-FC19476469) and the Cytochrome *b* sequence is available from GenBank (Accession number MH093593).

**Measurements of holotype.** Body mass 45 g, head and body 124 mm, tail 24 mm, hindfoot length 16.4 mm, condylobasal length of skull 30.4 mm, maxillary tooth row 11.6 mm, breadth of braincase 15.2 mm, height of braincase 9.2 mm, breadth of rostrum over canines 4.1 mm, breadth of rostrum over molars 8.3 mm, length of humerus 14.1 mm, width of humerus 9.7 mm, greatest length of pelvis 22.1 mm, breadth of pelvis 7.5 mm.





**Fig. 3.** Head (a) in lateral view, tip of nose (b) in dorsal (left) and ventral (right) views, and ventral side of tail in *Talpa martinorum* n. sp. Note that the palpebral fissure is covered by transparent skin (a). Museum vouchers PMS 25631 (a), ZFMK 2017.1152 (b) and ZFMK 2017.1151 (c). Not to scale.

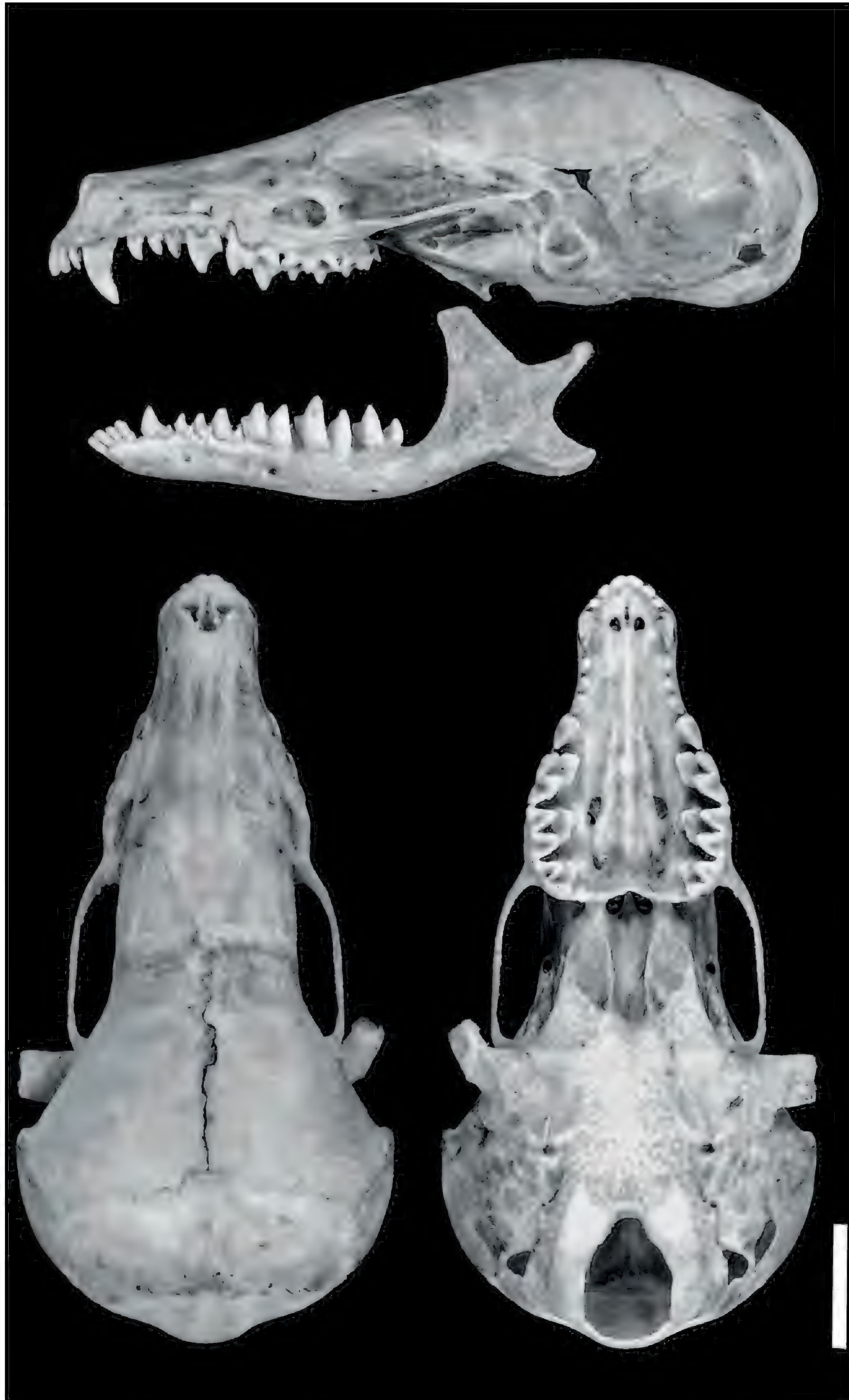
**Diagnosis.** A member of the subgenus *Talpa*. Medium-sized species with palpebral fissure sealed by a transparent skin (Fig. 3a). First upper molar ( $M^1$ ) lacks parastyle (Fig. 6a); the mesostyle is indistinctly bifurcate (Fig. 6a). Pairwise interspecific *p*-distances ( $> 9\%$ ) are within the range observed between other species of moles (e.g., within *Talpa*, interspecific distances average ca. 12%).

**Paratypes.** Skins, skulls, postcranial skeletons, tissue samples in ethanol and isolated DNA; voucher NMNHS 1053 is represented by a skull and a tissue sample, and vouchers NMNHS 1049–1052 are submerged in ethanol. Specimens were collected on Mt. Strandzha, Bulgaria: Velika, 1 female, collected on 23.09.2011 by N. Nedyalkov (NMNHS 1053), 1 female, collected on 01.05.2017 by N. Nedyalkov & B. Kryštufek (PMS 25631); Gramatiko-vo, 2 males, collected on 25.04.2017 by N. Nedyalkov & B. Kryštufek (NMNHS 1047, 1048); Vizitsa, 1 male, collected on 27.04.2017 by N. Nedyalkov & B. Kryštufek (ZFMK-MAM-2017.1150); Kondolovo, 1 male, collected on 28.04.2017 by N. Nedyalkov & B. Kryštufek (ZFMK-MAM-2017.1151); Fazanovo, 1 male, collected on 30.04.2017 by N. Nedyalkov & B. Kryštufek (ZFMK-MAM-2017.1152); Pismenovo, 1 male, 1 female, collected on 01.05.2017 by N. Nedyalkov & B. Kryštufek (PMS 25632, 25633); Chengene skele, Burgas, 1 male, 1 female, collected on 19.11.2017 by Nedko Nedyalkov (NMNHS 1049, 1050), Uzungeren, Burgas, 2 males, collected on 19.11.2017 by Nedko Nedyalkov (NMNHS 1051, 1052). Paratype voucher numbers for ethanol-fixed tissue samples (ZFMK-TIS-23033 to -23037 and ZFMK-TIS-33755 to -33758), and for extracted DNA are given in Appendix 2.

**Measurements of paratypes.** Reported are mean  $\pm$  standard deviation (minimum–maximum, sample size). Linear measurements are in mm, body mass in grams. Body mass  $58.31 \pm 4.06$  (52.5–65, 8), head and body  $126.75 \pm 3.196$  (124–134, 8), tail  $27.88 \pm 3.137$  (24–32, 8), hind foot  $16.91 \pm 0.861$  (15.0–17.4, 7), condylobasal length of skull  $31.80 \pm 0.747$  (30.3–33.1, 9), maxillary tooth row  $12.07 \pm 0.224$  (11.8–12.4, 9), breadth of braincase  $15.47 \pm 0.300$  (14.9–15.9, 9), height of braincase  $9.028 \pm 0.323$  (8.6–9.5, 9), breadth of rostrum over canines  $4.41 \pm 0.088$  (4.3–4.5, 9), breadth of rostrum over molars  $8.50 \pm 0.158$  (8.3–8.8, 9), greatest length of pelvis  $23.98 \pm 0.564$  (23.3–24.7, 6), breadth of pelvis  $7.82 \pm 0.366$  (7.4–8.3, 6), length of humerus  $13.93 \pm 0.186$  (13.7–14.2, 6), width of humerus  $10.42 \pm 0.132$  (10.2–10.6, 6).

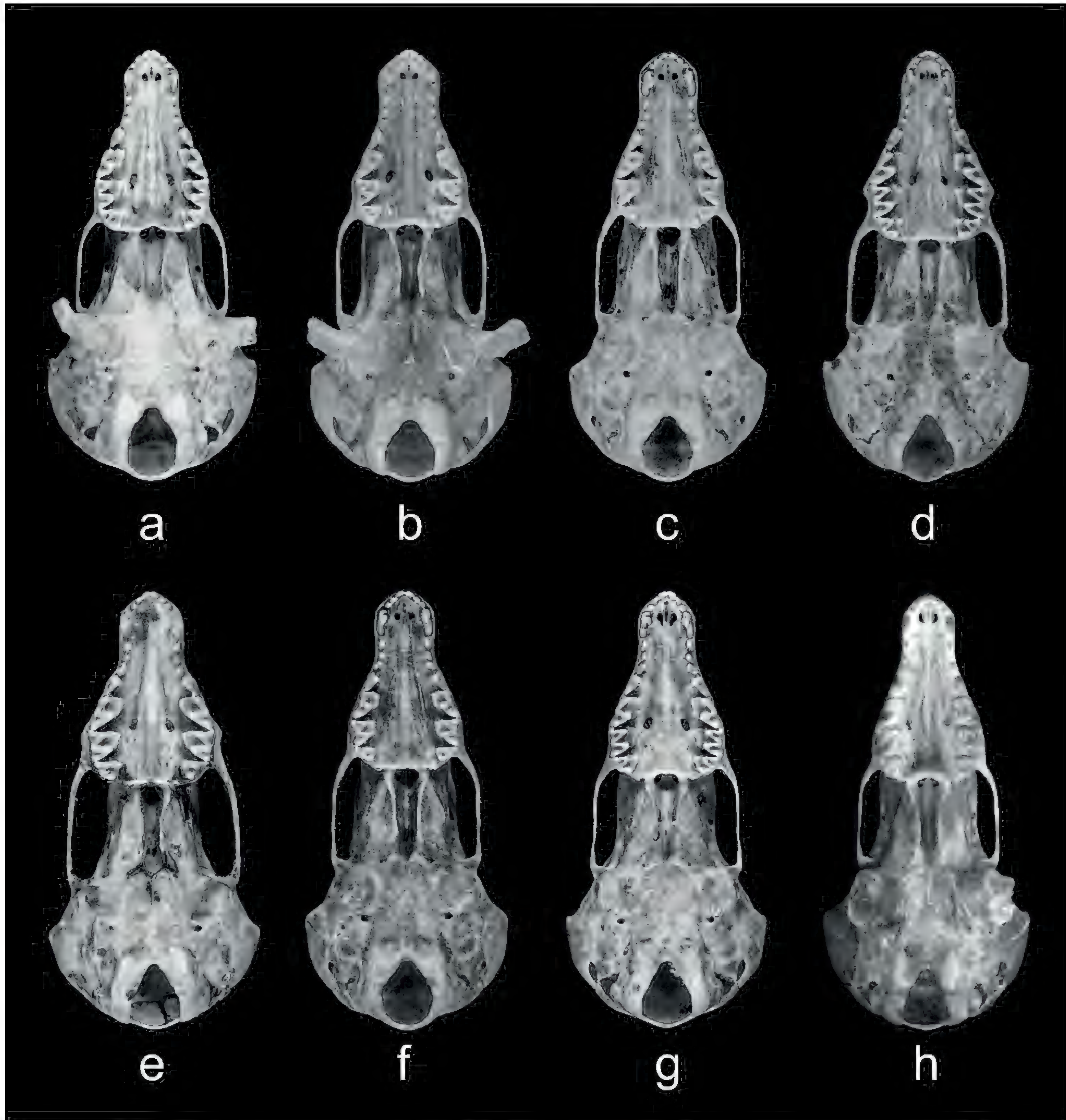
**Description.** *Talpa martinorum* n. sp. is of about the same external appearance and body proportions as *T. europaea* (Miller 1912). The tail is rather short (18–26% of head and body length) and densely covered by up to 6.5 mm long bristles (Fig. 3c). Pelage is dense and velvety, 7.0–8.0 mm long on the back, 4.5–6.0 mm ventrally. Fur is blackish dorsally and slightly lighter and with slate shades ventrally. A skin PMS 25632 has an irregular buff strike (21 mm long and up to 3.5 mm wide) on the posterior abdomen. Hairs around the eye are short and lighter, whitish or buff. The tip of the snout is pink to grey, covered by short hairs. There is a reverse triangle of bare skin behind the rhinarium. The tail is usually blackish. Fore foot is 12.6–14.3 mm broad. The skull (Fig. 4, 5a) shows no peculiarities and is of average size and shape overall. Rostrum is moderately robust; width across the canines accounts for 13.3–14.5% and across the molars for 25.4–27.7% of condylobasal length. Maxillary tooth





**Fig. 4.** Skull and mandible of the type specimen of *Talpa martinorum* sp. n. ZFMK 2017.1149. Scale bar = 5 mm.





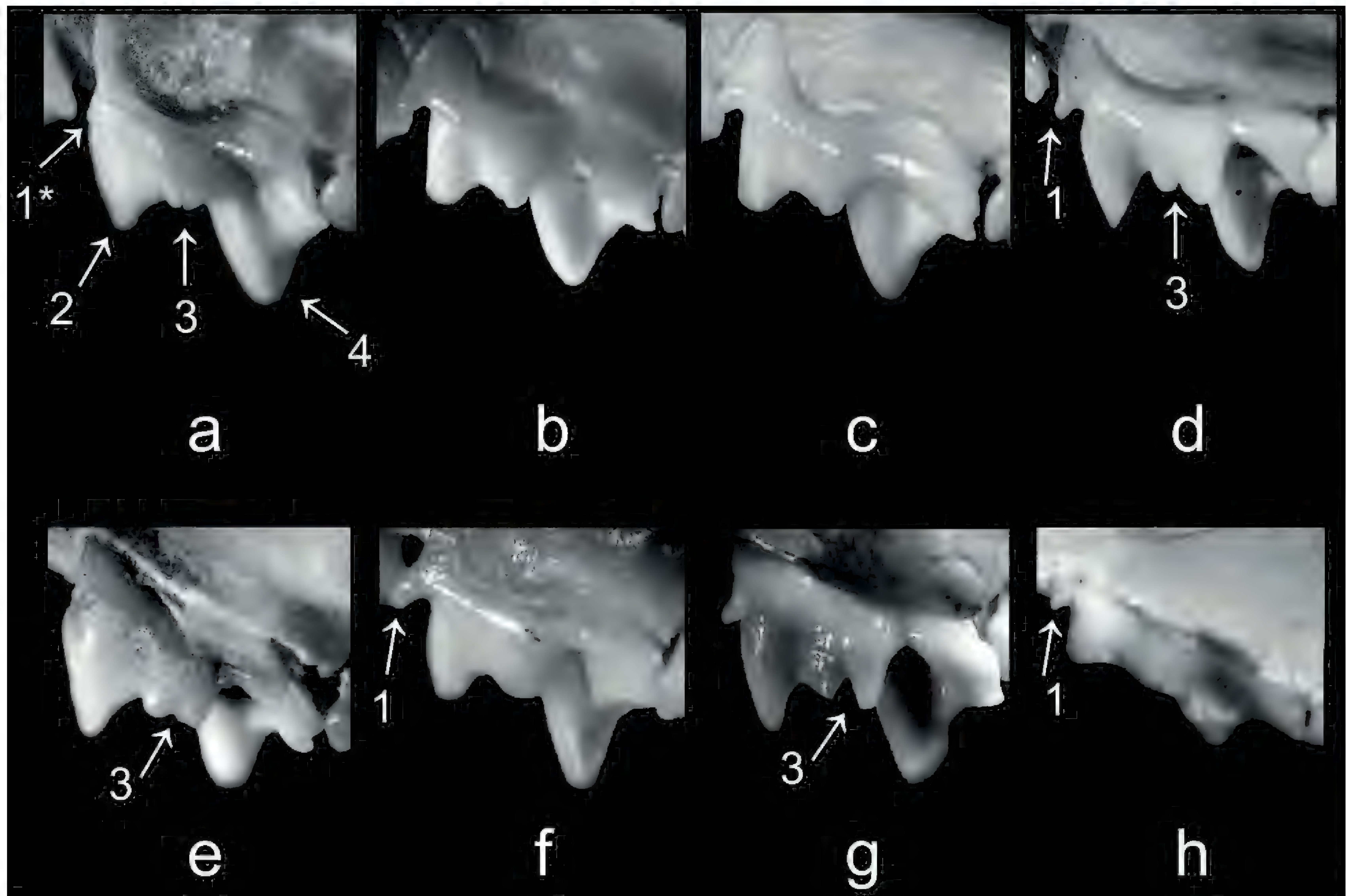
**Fig. 5.** Ventral cranium of species of *Talpa*: (a) *T. martinorum* n. sp. ZFMK 2017.1149 (greatest length of skull = 31.2 mm), (b) *T. europaea* ZFMK 2014.748 (35.8 mm), (c) *T. aquitania* ZFMK 2005.194 (35.6 mm), (d) *T. occidentalis* ZFMK 2005.301 (33.4 mm), (e) *T. romana* ZFMK 66.304 (37.7 mm), (f) *T. caeca* ZFMK 2005.268 (31.2 mm), (g) *T. stankovici* ZFMK 98.709 (34.1 mm), (h) *T. levantis* PMS 21658 (30.8 mm).

row equals to 37.3–38.9% of condylobasal length. The braincase is rather deep and the height of neurocranium makes up 26.9–30.3% of condylobasal length. The posterior margin of palatine is usually anterior to the imaginary line connecting the posterior alveolar margins of 3<sup>rd</sup>

upper molars, and the anterior border of the infraorbital foramen is above the 2<sup>nd</sup> upper molar (Fig. 4).

All three morphotypes of the pelvis were recorded in *T. martinorum* n. sp. The most frequent is the intermediate morphotype (n=13; own material combined with data in Popov & Milchev 2001), followed by the cae-





**Fig. 6.** Lateral view of left upper molar in species of *Talpa*: (a) *T. martinorum* n. sp. ZFMK 2017.1149, (b) *T. europaea* ZFMK 2007.006, (c) *T. aquitania* ZFMK 2005.160, (d) *T. occidentalis* ZFMK 2005.303, (e) *T. romana* ZFMK 1972.202, (f) *T. caeca* ZFMK 1966.310, (g) *T. stankovici* ZFMK 2005.326, (h) *T. levantis* PMS 10650. Anterior is to the left. Not to scale. 1 – parastyle, 2 – paracone, 3 – mesostyle, 4 – protocone. Note that the parastyle is missing in *T. martinorum* sp. n. (1\*).

coidal morphotype (n=10) and the europaeoid morphotype (n=2). The sezamoidal *os falciformis* is robust in its proximal part.

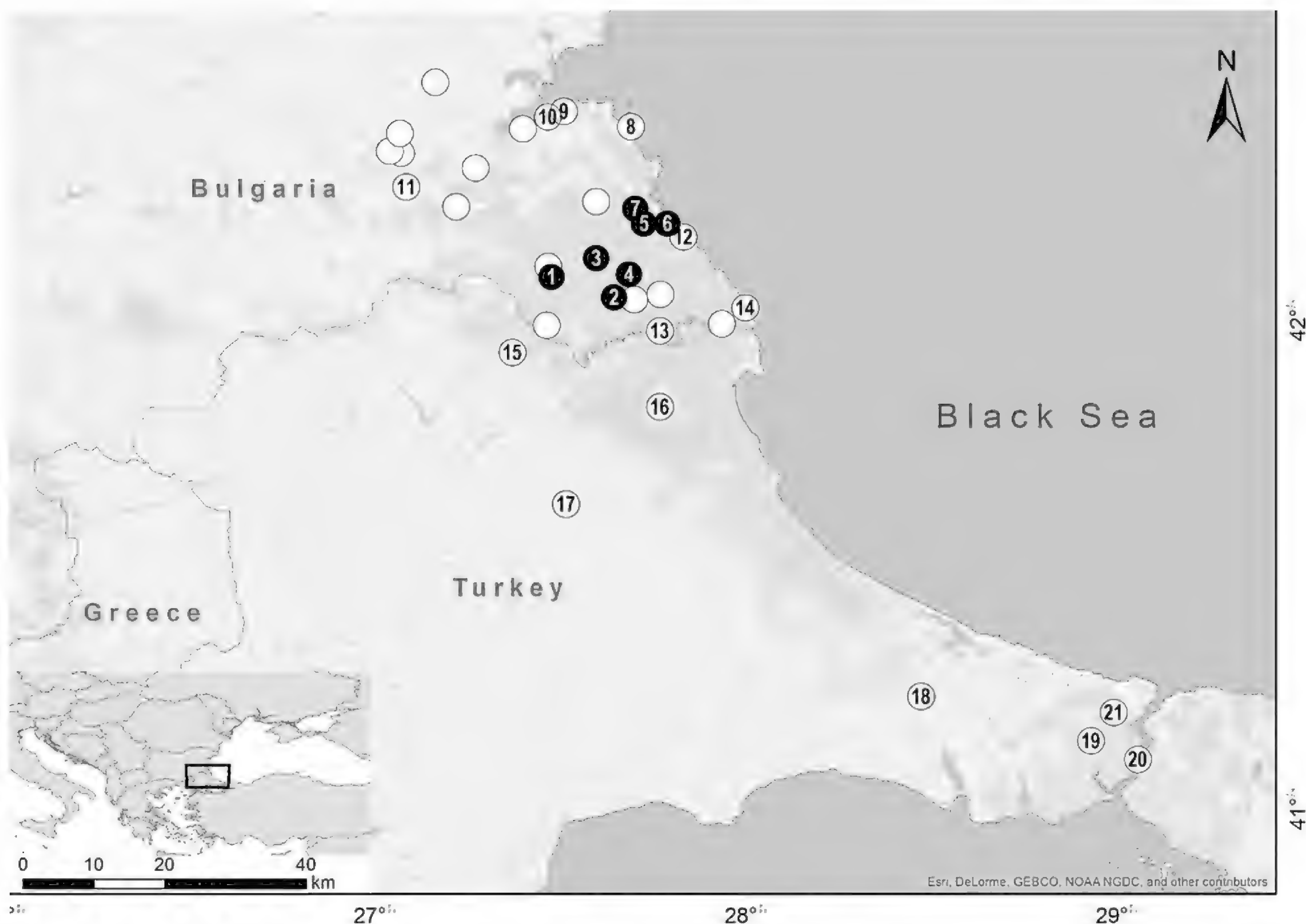
Incisors are of decreasing size with 1<sup>st</sup> incisor being nearly twice as large as 3<sup>rd</sup> incisor, which is the smallest. The molars are robust, and the 3<sup>rd</sup> molar is particularly large. The 1<sup>st</sup> upper molar entirely lacks the parastyle (Fig. 6a). The 1<sup>st</sup> lower premolar has a prominent distal cusp; the 4<sup>th</sup> lower premolar lacks metaconid, and the 3<sup>rd</sup> lower molar is always without hypoconulid while the entocristid is present only exceptionally. Oligodonties were present on three skulls out of nine studied: both 1<sup>st</sup> upper premolars are missing in ZFMK-MAM-2017.1150, left 1<sup>st</sup> upper premolar is missing in PMS 25632, and left 1<sup>st</sup> upper and 2<sup>nd</sup> lower premolars are missing in PMS 25631.

**Comparison.** Morphologically, *T. altaica* (subgenus *Asioscalopus*) is peculiar by its large size, short tail, slim skull (Fig. 2) and weak dentition with a reduced 1<sup>st</sup> upper molar (Stroganov 1957; Zaytsev et al. 2014). Differences between *Asioscalopus* and the subgenus *Talpa* are so

obvious that no comparison with *T. martinorum* n. sp. is required.

In Thrace, *T. martinorum* n. sp. can be safely differentiated from *T. europaea* by (i) a sealed palpebral fissure (open in *T. europaea*), (ii) absence of parastyle on 1<sup>st</sup> upper molar (present in *T. europaea*; Fig. 6b), and (iii) smaller size. Ranges for the two species overlap only marginally; dimensions of *T. europaea* are from Thrace in Bulgaria and Turkey (Osborn 1964; Doğramacı 1989a,b; Vohralík 1991; Popov & Miltchev 2001): body mass (in grams) 43–65 in *T. martinorum* n. sp. (own material and data in Doğramacı 1988) vs. 60–105 in *T. europaea*; condylobas-al length (in mm) 29.3–33.1 in *T. martinorum* n. sp. (own material and data in Osborn 1964; Doğramacı 1988; Popov & Miltchev 2001) vs. 32.4–37.0 in *T. europaea*; length of pelvis (in mm) 21.5–25.0 in *T. martinorum* n. sp. (own material and data in Doğramacı 1989b; Vohralík 1991; Popov & Miltchev 2001) vs. 24.9–30.1 in *T. europaea*; length of humerus (in mm) 12.9–14.9 in *T. martinorum* n. sp. (own material and data in Vohralík 1991; Popov & Miltchev 2001) vs. 14.5–17.8 in *T. europaea*. Molars





**Fig. 7.** Records of *Talpa martinorum* n. sp. in Bulgaria (BG) and Turkey (TR). Localities with known mitochondrial genetic identity are shown as black circles. Elevation is parenthesized. Legend: 1 – BG, Mt. Strandzha, Zvezdets (295 m); 2 – BG, Mt. Strandzha, Gramatikovo (210 m); 3 – BG, Mt. Strandzha, Vizitsa (274 m); 4 – BG, Mt. Strandzha, Kondolovo (298 m); 5 – BG, Mt. Strandzha, Fazanovo (106 m); 6 – BG, Mt. Strandzha, Velika (54 m); 7 – BG, Mt. Strandzha, Pismenovo (9 m); 8 – BG, Sozopol (50 m); 9 – BG, Burgas, Chengene skele (sea level); 10 – BG, Burgas, Tvarditsa, Uzungeren (4 m); 11 – BG, Valchanovo (300 m); 12 – BG, Tsarevo (40 m); 13 – BG, Lopushna Reserve (250 m); 14 – BG, Sinemorets, Silistar (40 m); 15 – TR, Kırklareli, Dereköy; 16 – TR, Kırklareli, Demirköy; 17 – TR, Kırklareli, Pınarhisar; 18 – TR, Subaşı; 19 – TR, Kagithane Dere; 20 – TR, Rumeli Hisar; 21 – TR, Bahçeköy. Corresponding references: localities 1–7, 9, 10, 12: own data; 8: Vohralík (1991); 11, 13, 14: Popov & Miltchev (2001); 15–17, 21: Doğramacı (1988); 18 – Collection H. Vierhaus (ZFMK); 19, 20 – NMNH. Localities with no numbers are unspecified in Popov & Miltchev (2001). Museum vouchers from the localities 18–20 are labelled as *T. caeca*; published records were classified as *T. caeca levantis* (pts. 15–17) or *T. levantis* (the remaining).

are relatively larger in *T. martinorum* n. sp. (dimensions of 3<sup>rd</sup> upper molar: 1.46–1.61 × 1.96–2.17 mm) than in *T. europaea* (1.29–1.59 × 1.77–2.24 mm; specimens from various parts of Europe). Pelvis in *T. europaea* is either europaeoid or intermediate but never caecoid (Petrov 1971b; Popov & Miltchev 2001).

*Talpa martinorum* n. sp. is well characterized by the absence of a parastyle on the 1<sup>st</sup> upper molar (Fig. 6a). Parastyle is present in the majority of species of *Talpa*, specifically in *T. europaea* (Fig. 6b), *T. aquitania* (Fig. 6c), *T. occidentalis* (Fig. 6d), *T. caeca* (Fig. 6f), *T. stankovici* (Fig. 6g), *T. levantis* (Fig. 6h), *T. davidiana*, *T. talyschenensis*, and *T. caucasica*. *Talpa romana*, which clearly lacks

the parastyle (Fig. 6e), can be reliably differentiated from *T. martinorum* n. sp. by the robust rostrum (Fig. 5e) and large 3<sup>rd</sup> upper molar (1.67–2.20 × 1.87–2.72 mm).

*Talpa martinorum* n. sp. can be unambiguously set apart from all the remaining species of the genus *Talpa* by the nucleotide sequence of the Cyt *b* gene.

**Distribution.** The distribution range of *T. martinorum* n. sp. extends along the south-western Black Sea coast from Burgas in Bulgaria to Istanbul in European Turkey, covering Mt. Strandzha (also Strandja in Bulgarian; Istranca in Turkish) in Bulgaria and Turkey, and the forested coastal belt between the southern foothills of Mt. Istranca and the city of Istanbul (Fig. 7). Records





**Fig. 8.** Vladimir and Evgeniya Martino near their home in Topčidersko Brdo (part of the city of Belgrade), Serbia, in early 1930s. Courtesy by Georgy Bakhtadze.

associated with published Cyt *b* sequences are all from Strandzha in Bulgaria. *Talpa martinorum* n. sp. is parapatric or allopatric with respect to *T. europaea* which is widespread in the lowlands further west. For the distribution range of *T. europaea* see Osborn (1964), Doğramacı (1989a), Vohralík (1991), and Popov & Miltchev (2001). The identity of small blind moles on the Asiatic side of the Bosphorus strait (Osborn 1964) is not known. All moles from north-western Anatolia sequenced so far have the molecular profile of *T. levantis* (vicinity of Zonguldak; Bannikova et al. 2015) and show a distinct parastyle on 1<sup>st</sup> upper molar (vicinity of Bolu and Bursa).

**Habitat.** *Talpa martinorum* n. sp. is a fossorial mole of similar habitat requirements as other species of the subgenus *Talpa* (cf. Niethammer & Krapp 1990). Characteristic mounds of unearthed soil (molehills) are a common feature in Mt. Strandzha. Specimens were captured in mesic meadows, pastures and orchards on deep medium-textured and well-drained soils (zheltozem and cinnamonic forest soils; Shishkov & Kolev 2014) in hilly regions, on the edges of arable land and on abandoned fields, in light black soil on low alluvial plains, in oak woodland and forests of river floodplains (own data as well as Osborn 1964 and Popov & Miltchev 2001). Altitudinal range is from near sea level up to at least 445 m.

**Etymology.** *Talpa martinorum* n. sp. is an eponym to Vladimir Emmanuilovich Martino (Владимир Эммануилович Мартино, 1888–1961) and Evgeniya Veniaminovna Martino (Евгения Вениаминовна Мартино, 1894–1979) née Stepanova (Степанова), ethnic Russians who in 1920 escaped the October Revolution by emigrating to the Kingdom of Serbs, Croats and Slovenes (Kingdom of Yugoslavia since 1929). In politically insecure and frequently violent Eastern Europe of the 20<sup>th</sup> century, the Martinos were refugees for more than three decades. In 1949 they moved to Bulgaria and in 1955 returned to Russia (at that time still Soviet Union). Inspired by G. S. Miller's (1912) "Catalogue of the Mammals of Western Europe" they initiated mammal research in south-eastern Europe and named, among others, two Balkan endemics: *Dinaromys bogdanovi* (V. Martino & E. Martino, 1922) (Martino & Martino 1922: 413) and *Talpa stankovici* V. Martino & E. Martino, 1931 (Martino & Martino 1931: 53) (Fig. 8). While Vladimir had a degree in Biology from the University in Novorossiysk (1913), Evgeniya had no formal academic education. Despite this, she attained competency in mammalogy and successfully collaborated with her spouse, both in the field and cabinet. Although they published several joint papers (as V. and E. Martino), the contribution by Evgeniya is mainly ignored and she is nearly anonymous today (cf. Beolens et al. 2009). At least nine subspecific names for mammals with the epithet *martinovi* (see Appendix 3) were proposed by mammalogists between 1935 and 1971, and all are eponyms to Vladimir Martino. With the name *martinorum* n. sp. we stress the equal share by Evgeniya in the tandem "V. et E. Martino" and correct the injustice done to her contribution in the past decades. Along with Dorothea Bate (1878–1951) and Gabriele Neuhäuser (1911–1998) Evgeniya was one of the early women who studied the taxonomy of Palaearctic mammals already between the two great wars. In addition to their publications, a renowned legacy of Vladimir and Evgeniya Martino is their meticulously prepared and carefully labelled mammal collection, deposited primarily in the Natural History Museum London and the Zoological Institute and Museum of the Russian Academy of Sciences in St. Petersburg. For biographies of Vladimir Martino, see Mezentsev (1961), Paspalev (1962), Pusanov (1962), Zimmermann (1962), Gus'kov (1965), Taranenko (1999), and Boreiko (2001).

## DISCUSSION

During the Pleistocene climatic changes over the last ca. 2.6 My, temperate species have endured glacial maxima in geographically restricted refugial areas. A legacy of the repeated extinctions of northern populations on the one hand, and the long-term persistence in southern refugia on the other hand is a number of taxa with restricted



distributions in the former glacial refugia (Hewitt 2000). Contemporary biogeographic pattern of the genus *Talpa* obviously results from the allopatric evolution in such constrained refugia. Only two mole species (*T. altaica* and *T. europaea*) have extensive distribution ranges in temperate and southern boreal regions of Europe and western Asia, while the remaining ten or so species occupy small areas along the southern edge of the distribution range of the genus (Bannikova et al. 2015). The new species from Thrace, with its small distribution range, is therefore well nested within a broader biogeographic pattern of the western Palaearctic.

Mammals endemic to the Balkan Peninsula, which include a mole *T. stankovici* and several rodents, are restricted to the topographically rough south-west Balkans (Kryštufek 2004). *Talpa martinorum* n. sp. therefore provides the first evidence on speciation of a mammal in the extreme eastern part of the peninsula. Besides, our new evidence also corroborates an earlier assumption on the persistence of multiple independent refugia inside the topographically complex Balkan refugium (cf. Kryštufek et al. 2007).

The new species shows no close phylogenetic links with the Balkan endemic *T. stankovici* nor with the Balkan-Italian *T. caeca*. Instead, *T. martinorum* n. sp. forms a (weakly supported) clade in the Cyt-*b* tree containing also the widespread *T. europaea* and two endemics from Western Europe, *T. aquitania* and *T. occidentalis*. Biogeographically, it is straightforward to interpret this finding. Inside the Balkan refugium there was no evolutionary divergence of an ancestral mole to *T. martinorum* n. sp. and either *T. stankovici* or *T. caeca*. Instead, *T. martinorum* putatively originated from a small peripheral fragment population of a taxon ancestral also to *T. europaea*. The process replicates itself in each of the three major southern European refugia, namely with *T. aquitania* and *T. occidentalis* in the west, with a deeply divergent phylogeographic lineage of *T. europaea* in northern Italy (Feuda et al. 2015), and finally in the eastern part of the Balkan refugium with *T. martinorum* n. sp. (this study). The observed pattern fits well the hypothesis by Bilton et al. (1998) on Mediterranean refugia as areas of endemism rather than sources of postglacial northward recolonizations. Based on molecular clock estimates of divergences between *T. europaea*, *T. aquitania* and *T. occidentalis* (1.88–3.71 Mya; Bannikova et al. 2015; Feuda et al. 2015; Nicolas et al. 2017b), the most recent common ancestor to *T. martinorum* n. sp. and *T. europaea* must be of Early Pleistocene age or older. Late Pliocene small moles from Varshets in north-western Bulgaria, classified as *T. cf. levantis*, closely resemble *T. martinorum* n. sp. by their small size and the 3<sup>rd</sup> upper molar with no parastyle and with an undivided mesostyle (Popov 2004). Middle Pleistocene strata of Yarimburgaz Cave near Istanbul, i.e., inside the contemporary range of the new species, also yielded a small species of mole

tentatively identified as *T. levantis* (Santel & Königswald 1998). Fossil evidence therefore provides strong support for a long persistence in the eastern Balkan refugium of a mole most similar to the current *T. martinorum* n. sp.

Molecular evidence (Bannikova et al. 2015; this study) so far did not yield any support for the earlier assumption that moles colonized southeast Europe via an intermittent Bosphorus land bridge during one of the low sea level phases (Vohralík 1991; Kryštufek & Vohralík 2001). The alternative submergences and emergences of the Bosphorus Strait enabled migrations of mammals from Europe to Asia (e.g., *Glis glis*; Helvaci et al. 2012), from Asia to Europe (e.g., *Microtus hartingi*; Kryštufek et al. 2009), or in both directions (*Crocidura leucodon*; Dubey et al. 2007). As shown by sedimentological evidence, however, the Bosphorus land bridge emerged as a permeable barrier only in the Middle Pleistocene (Kerey et al. 2004) and therefore postdates the postulated split between *T. martinorum* n. sp. and *T. europaea* (see discussion above). Therefore, even if moles from Asia would colonize Europe via the Bosphorus land bridge, they would face an established congeneric species in the new habitats. However, such speculations should be taken with a grain of salt. So far, none of the moles in the Bosphorus region on either side of the strait have been screened genetically. A denser sampling in that particular part of Turkey is therefore a necessity for a more holistic understanding of mole evolution in this biogeographically dynamic region.

**Acknowledgements.** We thank Jevgeni Shergalin for help with biographic information on Vladimir and Evgeniya Martino, and Georgy Bakhtadze for providing Fig. 8. Franc Janžekovič ran analyses in SPSS Statistics, Mojca Jernejc Kodrič processed the skeletal material of the new species, and Hannah Petersen performed the wet-lab work. B. K. acknowledges the curators who made the study of museum vouchers under their responsibility possible for him: the late William Stanley (FMNH), the late Svetoslav Obratil (ZMBiH), Linda Gordon (NMNH), Paula Jenkins (NHML), the late Kurt Bauer and Friederike Spitzenberger (NMW), Haluk Kefelioğlu (OMU), and Nataliya Abramson and Alexandra Davydova (ZIN). Alexandr Pozdnyakov helped with references, Georgy Popgeorgiev with Fig. 7, Jörg Adrian provided photographs shown in Figs 4 and 5, and Henning Vierhaus donated owl pellet material from his own collection. B. K. acknowledges the financial support from the Slovenian Research Agency (research core funding no. P1-0255).

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## APPENDIX 1

### Comparative museum vouchers

Listed are museum vouchers with the appropriate collection numbers; see text for collection acronyms. Material is itemized by country and sorted alphabetically according to locality.

***Talpa altaica* Nikol'skiy, 1883** (Nikol'skiy 1883: 165). Russian Federation – ZFMK-MAM-1987.751 and 1987.752 from Akademgorodok, Novosibirsk Oblast.

***Talpa aquitania* Nicolas, Martínez-Vargas & Hugot, 2017** (Nicolas et al. 2017a: 641). France – ZFMK-MAM-2005.242 from Arles-sur-Tech, Département Roussillon. ZFMK-MAM-2005.156 to 2005.159 from vicinity of Blaye, Département Gironde. Spain – ZFMK-MAM-2005.203 to 2005.2005 from vicinity of Barbadillo de Pez, Province of Burgos. ZFMK-MAM-2005.201 from Burguete, Province of Navarra. ZFMK-MAM-2005.202 from Cameros, Sierra de Cebollera, Province of Logroño. ZFMK-MAM-2005.189 to 2005.200 from vicinity of Corconte, Province of Santander. ZFMK-MAM-2005.160 to 2005.166, 2005.169 to 2005.175, 2005.177 to 2005.179, and 2005.181 from Ramales de la Victoria, Province of Cantabria. ZFMK-MAM-2005.176 and 2005.180 from Lanetosa, Province of Vizcaya.

***Talpa caeca* Savi, 1822** (Savi 1822: 265). Bosnia and Herzegovina – PMS 7239 from Čemerno. PMS 7478 from Lake Boračko jezero, Mt. Prenj. ZMS 293 (type of *Talpa hercegovinensis* Bolkay, 1925; Bolkay 1925: 1) from Stolac. Greece – NHML 31.11.11.24 to 31.11.11.26 and 31.11.11.27 (type of *Talpa olympica* Chaworth-Musters, 1932; Chaworth-Musters 1932: 166), 31.11.11.28 to 31.11.11.31 from eastern slope of Mt. Olympus. Italy – ZFMK-MAM-2005.260 to 2005.263, 2005.268, and 2005.269 from Abetone Pass, Province of Pistoia. PMS 9813 from Caramanico, Province of Pescara. ZFMK-MAM-2005.266 and 2005.267 from vicinity of Colle di Nava, Province Imperia. ZFMK-MAM-2005.264 and 2005.265 from Osiglia, Province of Savona. Kosovo – PMS 7473 from Pavlov kamen, Mt. Šar planina. Macedonia – PMS 7475 from Derven Pass above Prilep. PMS 7474 from Magarevo, Bitola. Montenegro – PMS 7485 from Mt. Kom Vasojević. ZFMK-MAM-1966.310 from Mt. Lovćen. PMS 7523 from Morača. PMS 8131 from

Nikšić. Switzerland – ZFMK-MAM-1965.065 from Bergell, Canton Graubünden.

***Talpa caucasica* Satunin, 1908** (Satunin 1908: 5). Russian Federation – NMW 19943 to 19945 from Psebaj, Krasnodar krai, north-western Caucasus.

***Talpa davidiana* (Milne-Edwards, 1884)** (Milne-Edwards 1884: 1143). Iran – FMNH 111007 from 1 mile south of Divandarreh, Kurdistan. FMNH 96421, 96423 and 96424 (type of *Talpa streeti* Lay, 1965; Lay 1965: 227) from Hezar Darreh, Kurdistan. Turkey – FMNH 82136 and 82137, PMS 21503 from Bitlis, Tatvan. OMU 231 from Megabuti yaylası, Hakkari. NMW 20326 and 20327 from Cilo-Sat-Mts., Mergan Zoma, Hakkari. MNHN 1883.469 (type of *Scaptochirus davidianus* Milne-Edwards, 1884) from Meydanekbez, Gaziantep. OMU 166 and 232 from Otluca köyü, Hakkari. Israel – NHML M15277 (type of *Talpa chthonia* Bate, 1937; Bate 1937: 399), M16092 from the Upper Pleistocene layers of Tabun Cave.

***Talpa europaea* Linnaeus, 1758** (Linnaeus 1758: 52). Austria – ZFMK-MAM-2005.143, 2005.146, and 2005.185 from Kleinalm, Lower Tauern, Styria. Bosnia and Herzegovina – PMS 21511 from Gornji Malovan. Bulgaria – ZFMK-MAM-1938.146 from Bansko, Mt. Pirin. Germany – ZFMK-MAM-2005.342 from Bonn-Kessenich, NRW. ZFMK-MAM-2005.334 from Bonn-Lengsdorf, NRW. ZFMK-MAM-2007.006 from vicinity of Münster, NRW. ZFMK-MAM-2009.021 from Wahner Heide, Niederrheinische Bucht, NRW. ZFMK-MAM-2014.748 from Welldorf, Dueren, NRW. ZFMK-MAM-2002.138 from Wesseling-Urfeld, North Rhine-Westphalia (NRW). ZFMK-MAM-2005.139 from Angeln, Schleswig-Holsteinisches Hügelland, Schleswig-Holstein. ZFMK-MAM-2005.153 from Großhansdorf, Schleswig-Holstein. France – ZFMK-MAM-2005.084 and 2005.085 from St. Tropez, Pampelonne, Département Var. Italy – ZFMK-MAM-2005.086 from vicinity of Albenga, Province of Savona. ZFMK-MAM-2005.089 from Dego, Province of Savona. ZFMK-MAM-2005.066, 2005.074, 2005.075, and 2005.328 from Merano, Province of South Tyrol. ZFMK-MAM-2005.090 to 2005.093 from Pass Colle di Nava, Province of Imperia. ZFMK-MAM-2005.087 from Pass Col di Sistrere, the Cottian Alps (Alpi Cozie), Region of Piedmont. ZFMK-MAM-2005.088 from Pietralunga, Province of Perugia. Montenegro – PMS 393 from Lubnice, Mt. Bjelasica. Serbia – ZIN 33974 (Type of *Talpa europaea pančići* V. Martino, 1930; Martino 1930: 60) from Kraljevo. Slovenia – PMS 25634 from Mt. Pohorje.



***Talpa levantis* Thomas, 1906** (Thomas 1906: 416). Turkey – NHML 25.11.1991 (type of *Talpa caeca levantis*) from Altindere, Trabzon. NHML 6.5.1.1 to 6.5.1.4 from Çosandere, Trabzon. NHML 6.3.6.6 from Euthey, Trabzon. NHML 6.3.6.4; NMNH 327252 and 327253 from Meryemana, Trabzon. OMU 233, 234, and 236 to 242 from Bitlis, Tatvan. NMW 13042 and 13043 from Bolu. PMS 10299 from Kürtler, Samsun. PMS 21658 from 10 km east of Şavşat, Ardahan. NMW 19858 from Ulubey, Ordu. NMW 19859 from Yavuz-Kemal, Bicik, Giresun. PMS 11372 from Şehitler Geçidi, Mts. Giresun Dağları, Tamdere. NMNH 327263 and 327264, PMS 10650 from Mt. Ulu Dağ, Bursa.

***Talpa occidentalis* Cabrera, 1907** (Cabrera 1907: 212). Spain – ZFMK-MAM-2005.304 from 4 km south-west of Cantoral, Province of Burgos. ZFMK-MAM-2005.279 and 2005.280 from 1 km north-east of Cazorla, Province of Jaén. ZFMK-MAM-2005.271 to 2005.275 from Espinama, National Park Picos de Europa, Province of Cantabria. ZFMK-MAM-2005.290 to 2005.294, 2005.297, and 2005.298 from vicinity of Espinosa de los Monteros, Province of Burgos. ZFMK-MAM-2005.276 to 2005.278 from 7 km south-west of Lanetosa, Puerto de los Tomos, Province of Santander. ZFMK-MAM-2005.308 and 2005.309 from vicinity of Las Rozas, Province of Santander. ZFMK-MAM-2005.281 to 2005.286 from 10 km south of Rascafria, Province of Segovia. ZFMK-MAM-2005.299 to 2005.301 from Llánares de la Reina, Province of León. ZFMK-MAM-2005.301 and 2005.302 from 10 km south of Riano, Province of León. ZFMK-MAM-2005.314 from near Samosierra, Province of Segovia. ZFMK-MAM-2005.310 to 2005.313 from Sierra de Gredos, Province of Ávila. ZFMK-MAM-2005.270 from Paso di Somosierra, Sierra de la Guadarrama, Province of Segovia.

***Talpa romana* Thomas, 1902** (Thomas 1902: 516). Italy – PMS 9855 from Caramanico, Province of Pescara. ZFMK-MAM-1977.675 from Catanzano, Province of Calabria. ZFMK-MAM-1966.291 to 1966.302, 1966.305, 1966.306, and 2005.335 from Monte Gargano, Province of Puglia. ZFMK-MAM-1966.303 from the National Park Abruzzo. ZFMK-MAM-1966.304 from Pescasseroli, Province of L'Aquila.

***Talpa stankovici* V. Martino & E. Martino, 1931** (Martino & Martino 1931: 53). Greece – ZFMK-MAM-2005.322 to 2005.326 from Corfu, Ionian Islands. ZFMK-MAM-205.327 from 7 km south of Ioannina, Epirus. ZFMK-MAM-1963.680 and 1977.031 from Mt. Olympus. Macedonia – ZIN 34014 (type of *Talpa romana stankovici*) from Magarevo, Bitola. PMS 7488 from Derven Pass above Prilep. PMS 7491 to 7493 and 7502 from Mt. Galičica. ZFMK-MAM-1998.709 and PMS 7497 from Mt. Bistra. PMS 7499 from Mt. Kajmakčalan. PMS 7486 and 7487 from Prilep. PMS 7496 and 7503 from Popova šapka, Mt. Šar planina. PMS 7504, 7505, and 7507 from Resen. PMS 7495 and 7497 from Struga. Montenegro – PMS 3202, 3203, 3205 (type of *Talpa stankovici montenegrina* Kryštufek, 1994; Kryštufek 1994: 14) and 3207 from Ulcinj.

***Talpa talyschensis* Vereschchagin, 1945** (Vereschchagin 1945: 67). Iran– Ghilan, FMNH 96416 to 96419 from 12 km west of Chalus.



APPENDIX 2

**GenBank accession numbers.** Specimens of *Talpa martinorum* n. sp. sequenced in this study. List includes collecting data for the new sequences and GenBank accession numbers. See text for collection acronyms and Fig. 7 for locality numbers (Loc. No.).

Collection No.	Loc. No.	Latitude	Longi-tude	Field number	DNA voucher Tissue voucher	GenBank No.
NMS BG1	3	42.04736	27.64744	BG1	ZFMK-DNA-FC19476453 ZFMK-TIS-23033	MH093591
NMS BG2	3	42.04697	27.64782	BG2	ZFMK-DNA-FC19476461 ZFMK-TIS-23034	MH093592
ZFMK-MAM- 2017.1149	2	42.09068	27.47637	BG8	ZFMK-DNA-FC19476469 ZFMK-TIS-23035	MH093593
ZFMK-MAM- 2017.1150	1	42.12798	27.59862	BG9	ZFMK-DNA-FC19476382 ZFMK-TIS-23036	MH093594
ZFMK-MAM- 2017.1151	4	42.09424	27.68921	BG10	ZFMK-DNA-FC19476390 ZFMK-TIS-23037	MH093595
ZFMK-MAM- 2017.1152	6	42.19826	27.73069	BG14	ZFMK-DNA-FC19476398 ZFMK-TIS-33755	MH093596
PMS 25631	7	42.19739	27.79592	BG15	ZFMK-DNA-FC19476406 ZFMK-TIS-33756	MH093597
PMS 25633	5	42.2287	27.70733	BG17	ZFMK-DNA-FC19476422 ZFMK-TIS-33758	

APPENDIX 3

Eponyms to (Vladimir) Martino

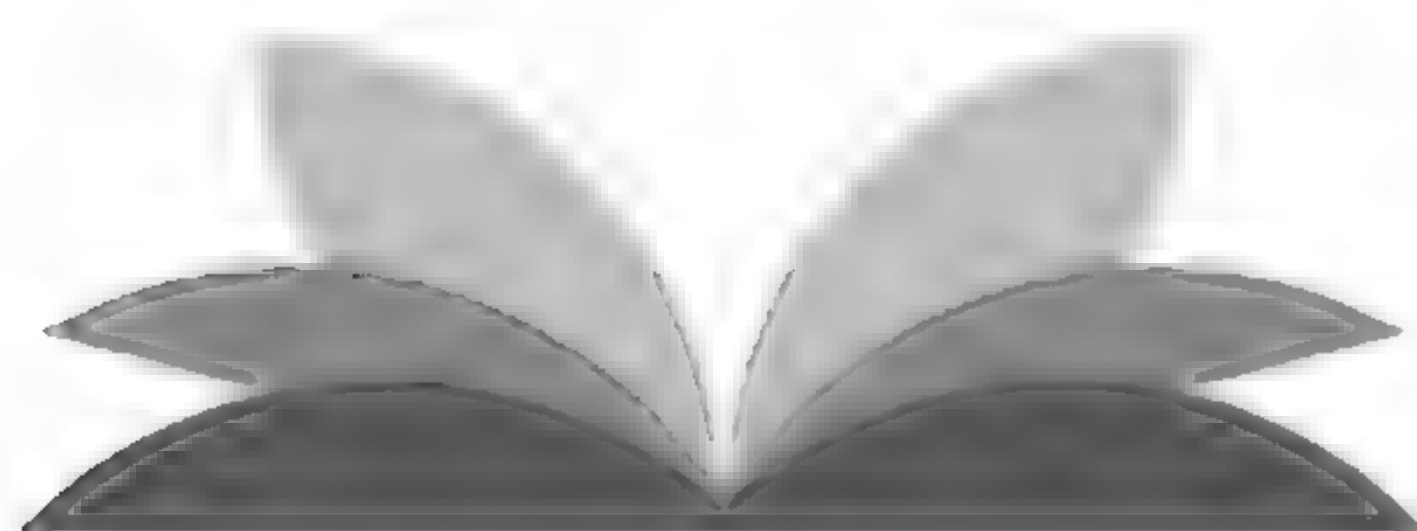
Names are arranged chronologically. Species name as is currently in use (ex Wilson & Reeder 2005) is in square brackets when appropriate.

*Pitymys subterraneus martinoid* Éhik, 1935 (Éhik 1935: 60) [*Microtus subterraneus*]  
*Sumeriomys guentheri martinoid* Petrov, 1939 (Petrov 1939: 363) [*Microtus guentheri*]  
*Rhinolophus ferrumequinum martinoid* Petrov, 1940 (Petrov 1940: 59)  
*Arvicola terrestris martinoid* Petrov, 1949 (Petrov 1949: 186) [*Arvicola amphibius*]

*Mustela erminea martinoid* Ellerman & Morrison-Scott, 1951 (Ellerman & Morrison-Scott 1951: 256)  
*Citellus citellus martinoid* Peshev, 1955 (Peshev 1955: 290) [*Spermophilus citellus*]  
*Glis glis martinoid* Mirić, 1960 (Mirić 1960: 36)  
*Spalax leucodon martinoid* Petrov, 1971 (Petrov 1971a: 13P)  
*Lynx lynx martinoid* Mirić, 1978 (Mirić 1978: 30)



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## Amphibian and reptilian records from south-central Mali and western Burkina Faso

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**Abstract.** Some amphibians and reptiles from southern Mali and southwestern Burkina Faso have been deposited in the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK) since the year 2000. Supplemented by some photographic voucher material they contain several remarkable, in some cases even new records for the two respective countries. Malian specimens were collected mainly in the region between Douentza and Bandiagara in the south-central part of the country, while those from Burkina Faso are from the Bobo Dioulasso area in the southwestern part of the country. Three amphibian species are new for Mali's faunal list (*Leptopelis bufonides*, *Ptychadena trinodis*, *Pyxicephalus* sp. as the first representative of its genus). Two specimens of a small-sized *Agama* species cannot yet be assigned to a described species with certainty but are in any case of zoogeographical interest. A specimen of *Chamaeleo gracilis* documents the second record of this species for Burkina Faso, the first one in the western part of the country. The slender blind snake *Leptotyphlops albiventer* is recorded for the first time for this country.

**Key words.** West Africa: Mali, Burkina Faso; herpetofauna, first country recordss.

### INTRODUCTION

While the forests of the Upper Guinean region of West Africa have been the focus of much herpetofaunal attention in recent decades (e.g., Penner et al. 2011), many areas of landlocked West Africa remain under-surveyed. Some work has been done on a number of these countries, for example, Guinea-Bissau (Auliya et al. 2012), Senegal (Joger & Lambert 2002), Guinea (Böhme 2000, Rödel et al. 2004, Greenbaum & Carr 2005, Hillers et al. 2008, Böhme et al. 2011); relatively little, however, has been published on the herpetofauna of Mali and Burkina Faso when compared with their southern neighbours. For Mali, Joger & Lambert (1996, 1997) provided an annotated checklist and analysis of the diversity and biogeography of the herpetofauna, while Böhme et al. (1996) provided some additional records for both countries. Rödel (2000) described the West African frog fauna and listed country records for each species, including Mali and Burkina Faso. Chirio (2009) gave records for the geographic triangle formed by Niger, Benin and Burkina Faso where the border-crossing “W Transfrontier Biosphere Reserve” (“Réserve de Biosphère Transfrontalière du W”, RBTW) is situated. More recently, Trape & Mané (2006) and Trape et al. (2012) provided updated distribution maps at a one-degree scale for snakes and other reptiles respectively, for all West African countries. Mediannikov et al. (2012) revised the genus *Agama* all over West Africa with an integrative approach which is, however, partly in conflict with the results of Wagner et al. (2009) and Leaché

et al. (2014). Finally, Trape & Mané (2017) published a summarising paper on the snake fauna of Mali.

Here, we report on some herpetological voucher material from Mali and Burkina Faso (Fig. 1) that has entered the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK) in Bonn after 1996, since the publication of a first note on this topic happened 22 years ago (Böhme et al. 1996).

Our Malian records were made by Jeffrey Heath and two native collaborators (Seydou Moro and Oumar Pergourou, see below) in September 2009, July 2010 and on various occasions in 2011 and 2012 in the Dogon Province, southern Mali, at Sévaré near Mopti (14°32'N, 04°06'W) and in the following villages of the area between Douentza and Bandiagara:

– Anda near Douentza (14°49'N, 03°01'W) is nested at the base of a small rocky hill (inselberg). Between the inselbergs are sandy fields, but there are also some creeks and waterholes so that there are several microenvironments (Fig. 2).

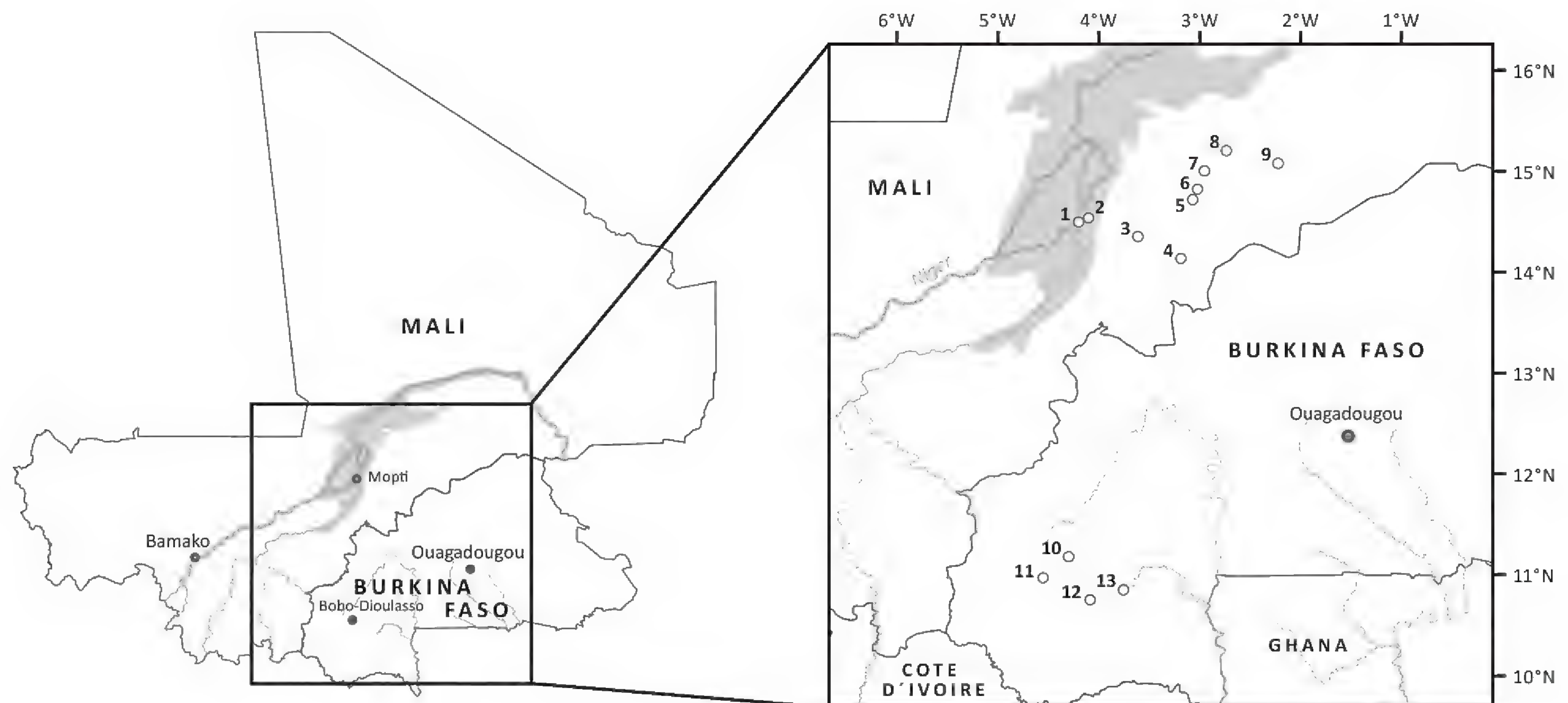
– between Douentza (15°00'N, 01°22'W) and Boni (15°07'N, 01°22'W) on pasture ground with wetlands;

– Pergué (14°85'N, 03°02'W) near Douentza (Fig. 3) which is on a rocky shelf forming part of an inselberg. In the outskirts of the village, to the south of the inselberg, there are sandy plains.

– Kikara (15°12'N, 02°44'W) near Douentza, on the northern slope of Gandamia inselberg (750 m a.s.l.), mountain top.

– Koporo-Pen (14°08'N, 03°11'W), sandy plains east of Bandiagara.





**Fig. 1.** Map of Mali and Burkina Faso. Inset: Study area. Localities (Mali): 1. Mopti; 2. Sévaré; 3. Bandiagara; 4. Koporo Pén; 5. Pergué village; 6. Anda village; 7. Douentza; 8. Kikara village; 9. Boni; (Burkina Faso); 10. Bobo Dioulasso; 11. 10 km SE Tiéfara; 12. Dérégoué; 13. Karankasso Vigué. Drawing: Morris Flecks.



**Fig. 2.** Anda village, Mali.



**Fig. 3.** Pergué village, Mali.

The area between Douentza and Bandiagara was visited several times, in 2009 (September), 2010 (July) and in 2011/2012, in the course of Dogon linguistic studies carried out by Jeffrey Heath in the Dogon Province. Some amphibians and reptiles were seen, photographed and – by focal sampling – collected. These voucher specimens are deposited in ZFMK's herpetological collection, as are the photographs in ZFMK's herpetological photo archive.

In 2015, J. Heath also visited Burkina Faso and was able to gather some photographic vouchers of herpetolog-

ical specimens which stemmed from Karankasso-Vigué (10°61'N, 03°54'W), southeast of Bobo Dioulasso, and from Dérégoué (locally also spelled Dérégboué; 10°45'N, 04°05'W, 295 m a.s.l.), 50 km east of Bobo Dioulasso.

From the latter locality (4 km NE) we also received some specimens collected in 1985 by Harald Schreiber and co-workers, who was earlier the responsible curator of the herpetological collection of the University of Saarbrücken (Paul Müller collection). Harald Schreiber and co-workers collected also 10 km SE of Tiéfara (10°58'N,



04°33'W), in Bobo Dioulasso and in Ouagadougou itself. In 2010, the entire Paul Müller collection which had initially been transported to the University of Trier, was finally deposited in Bonn where it is now integrated in the ZFMK herpetological collection (Böhme 2014). This small part of the Paul Müller collection together with the records made by J. Heath complements ZFMK's previous holdings from Burkina Faso and Mali which had been collected by Ulrich Joger, Harald Meier and Holger Meinig. Their materials which contained also interesting records including new ones for these two countries have been published earlier (Joger 1979, 1981, Böhme et al. 1996). The present paper is an update of these earlier contributions.

## COMMENTED SPECIES LIST

### AMPHIBIANS

#### *Xenopus (Silurana) tropicalis* (Gray, 1864)

**Burkina Faso:** ZFMK 93959–965, 4 km NE Dérégoué, gallery forest at Koba River.

The first record of this West African forest-dwelling pipid species (Loumont 1984, Rödel 2000) from Burkina Faso was published by Böhme et al. (1996) based on ZFMK specimens collected 1983 from Bobo Dioulasso by Harald Meier. Our newly acquired series from Dérégoué corroborates the distribution of this zoogeographical outlier far from the forested coast in the arid savannas of interior West Africa. However, the gallery forest enables its survival in this environment, as it has also been found in Senegambia (Böhme 1979) and northern Ivory Coast (Comoé National Park: Rödel 2000).

#### *Leptopelis bufonides* Schiøtz, 1967

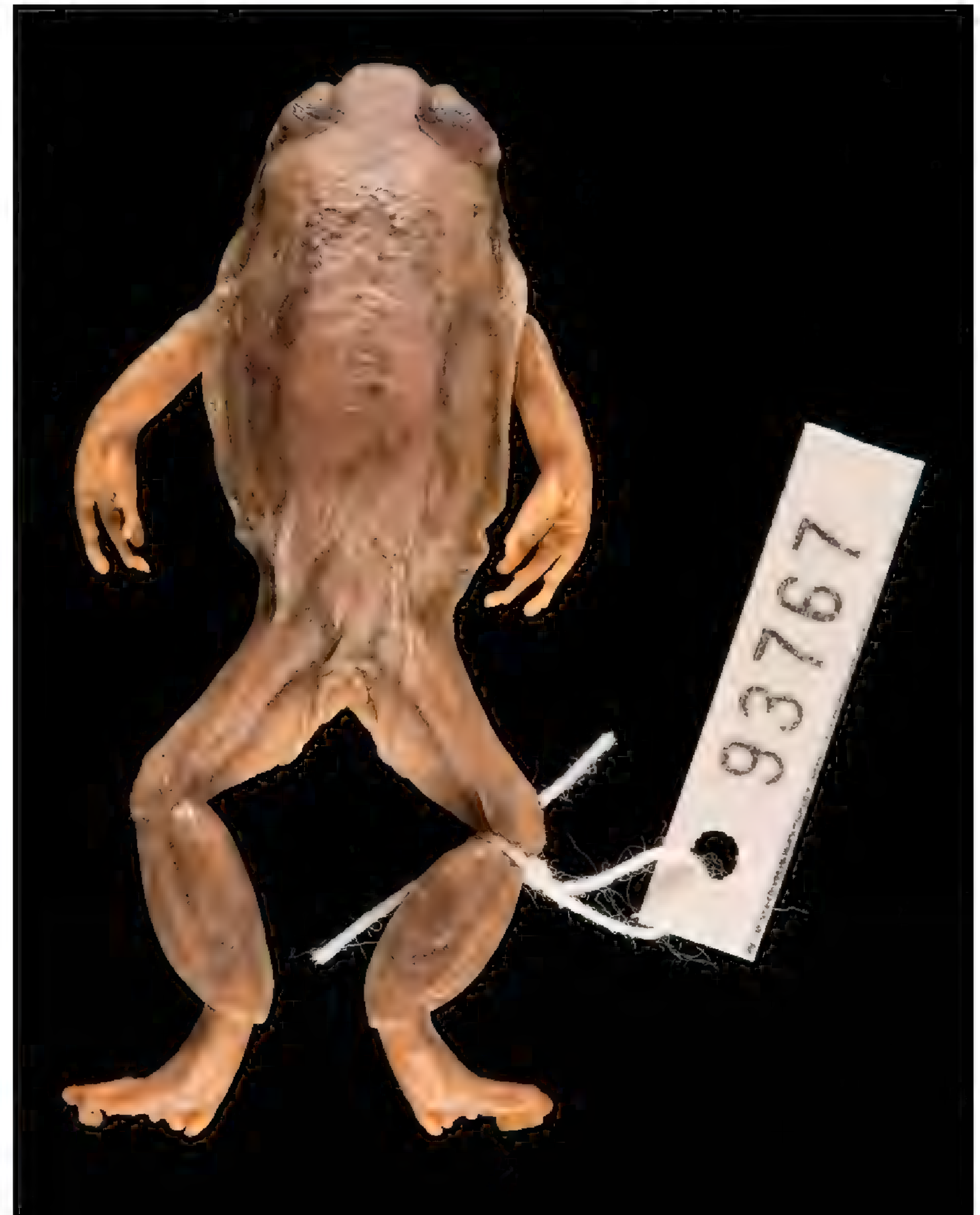
**Mali:** ZFMK 93766–767, from between Douentza and Boni, pasture ground with swamps.

Known from few localities from the open, relatively dry savannas of West Africa, and seemingly patchily distributed (Hillers et al 2008). Joger & Lambert (1996) indicated that it is likely to occur in Mali, since it is known from Senegal and Burkina Faso, see also Rödel 2000). However, our records listed here (Fig. 4) are apparently the first confirmed ones for Mali.

#### *Sclerophrys regularis* (Reuss, 1834)

**Burkina Faso:** ZFMK 93968–969, 10 km SE Tiéfora, gallery forest at Sinlo River; ZFMK 101292–293, Dérégoué.

A comment to be made on this widely distributed and common species refers to the generic nomenclature. After the partition of the collective genus *Bufo*, the Afrotropi-



**Fig. 4.** *Leptopelis bufonides* from between Douentza and Boni, Mali.

cal species were accommodated in an own genus *Amietophrynus* (Frost et al., 2006), a name that has been in use since then and has been established in numerous papers which means that nomenclatural stability was again achieved. Recently, however, Ohler & Dubois (2016) found an old specimen described as *Sclerophrys capensis* Tschudi, 1838 to be assignable to *Bufo* (or respectively *Amietophrynus*) *rangeri*, and synonymized the latter generic nomen with *Sclerophrys*. They were right in stating that, despite only few citations, *Sclerophrys* was not a nomen oblitum, so that this name has currently to be used as the oldest available one for these toads.

#### *Phrynobatrachus* cf. *latifrons* Ahl, 1924

**Burkina Faso:** ZFMK 93966, 4 km NE Dérégoué, gallery forest at Koba River.

The taxonomy of these little puddle frogs is complicated since a sibling species from the more forested regions (*P. accraensis*) is involved. In addition, there are numerous synonyms to be evaluated. These frogs are in need of revision, so that our assignment above is tentative.





**Fig. 5.** *Ptychadena trinodis* from between Douentza and Boni, Mali. Left: ZFMK voucher; right: specimen not collected.



**Fig. 6.** Plate from Boettger (1881) showing the (presumably lost) type specimens of his *Rana* (currently *Ptychadena*) *trinodis* (lower left) and *Maltzania* (currently *Pyxicephalus*) *bufonia* (upper).

#### *Hoplobatrachus occipitalis* (Günther, 1859)

**Burkina Faso:** ZFMK 93958, 4 km NE Dérégoué, gallery forest at Koba River; ZFMK 93967, 10 km SE Tiéfora, gallery forest at Sinlo River.

A very common species in sub-Saharan Africa, entering both desert habitats in the north and forest habitats in the south. Represented by voucher material from several localities in the ZFMK collection (see Böhme et al. 1996).

#### *Ptychadena trinodis* (Boettger, 1881)

**Mali:** ZFMK 93770-771 from between Douentza and Boni, pasture ground with swamps.

According to Frost (1985) distributed from Senegal to the Democratic Republic of Congo, Mali being listed as one of the countries with published records (Rödel 2000). However, M.-O. Rödel (pers. comm.) kindly verified the identification of our specimens (Fig. 5) and informed us that they should actually be the first proven voucher specimens for Mali. The single holotype of this species (Fig. 6), collected by Hermann and Agnes von Maltzan for the Senckenberg Museum in Frankfurt am Main, seems to be lost as it is not included in the type list of this collection by Mertens (1967). For some details about the collectors see below under *Pyxicephalus*.





**Fig. 7.** Four specimens of *Pyxicephalus* sp. from between Mopti and Sévaré, Mali, to show the variability in color pattern. The specimen on lower left is a juvenile (not on scale).

### *Pyxicephalus* sp.

**Mali:** ZFMK 93763, 93772–773, Sévaré near Mopti.

Our new records are the first ones of this genus for Mali and bridge a large geographical gap between Senegal (Rufisque: Boettger, 1881; south of Rosso: Böhme et al. 2001), Gambia (Frost 2017) and Mauritania (Abdul Behru and Chlim: ZFMK vouchers: 76773 and 76781–782 respectively) on the one hand, and Benin and Nigeria (Rödel 2000, Nago et al. 2006) on the other. West African *Pyxicephalus* are in high need of revision. Currently, the West African populations of this frog are still assigned to *P. edulis* Peters, 1854 (type locality Mozambique!) (Rödel 2000, Böhme et al. 2001, Nago et al. 2006, Frost 2015), but Rödel (2000) who listed as westernmost occurrence only Nigeria, regarded it as not unlikely that the West African *Pyxicephalus* might not be *edulis* but a distinct species, citing an older personal communication by one of us (WB). Boettger (1881) described a Senegalese specimen as the sole member of his new genus *Maltzania* from Rufisque in westernmost Senegal (Fig. 7) and

assigned it to his new species *M. bufonia*. This is the oldest and geographically closest name applicable to the West African members of *Pyxicephalus*. Also Monard's (1951) name *reiensis* (from Rey Bouba, northern Cameroon) must be taken into consideration once a systematic revision of Central and West African *Pyxicephalus* will yield taxonomic differences between these two regions (for the East African forms see Scott et al. 2013). But if the Central and West African populations proved to be identical, Boettger's name would have high priority over that of Monard (1951). Figure 7 documents the variable colour pattern in the Malian population.

Boettger (1881) himself already regarded his often overlooked new genus *Maltzania* as closest to *Pyxicephalus*. He dedicated this name to Baron Hermann von Maltzan (1843–1892) and his wife, Baroness Agnes von Maltzan, who both had collected in Senegambia for the Senckenberg Museum in Frankfurt am Main. The single holotype of *M. bufonia* (Fig. 6) evidently shared the fate of the other new frog described by Boettger (1881) in the same paper, viz. *Ptychadena trinodis* (see above),



and seems to be lost, since it is not included in Mertens' (1967) type catalogue. Also, von Maltzan's frogs cannot be traced in the natural history museum of Waren/Mecklenburg, the so-called Maltzaneum (today called Müritzeum) which had been founded by him in 1866 (Gebhardt 1964, Hauff 2016).

*Hildebrandtia ornata* Nieden, 1907

**Mali:** ZFMK 93768-069, from between Douentza and Boni, pasture ground with swamps.

Despite its large distribution area in the sub-Saharan savanna belt, this species "is rarely encountered" (Rödel 2000), so our record is of faunistic interest.

*Amnirana galamensis* (Duméril & Bibron, 1841)

**Mali:** ZFMK 90468, between Douentza and Bandiagara.

*A. galamensis* is widely distributed in sub-Saharan Africa, the typical form (type locality Lake Galam in Senegal) being confined to West and Central Africa and replaced by *A. g. bravoana* in eastern Africa and further south. A photographic voucher from Burkina Faso is mentioned in the appendix (see below).

## REPTILES

*Pelusios castaneus* (Schweigger, 1812)

**Burkina Faso:** ZFMK 93957, 4 km NE Dérégoué, H. Schreiber and B. Basten, II.–IV. 1985.

The map sketch of *Pelusios castaneus* in Branch (2008) leaves Burkina Faso outside the distribution range of this species, while the text says only "from Senegal to northwestern Angola, and inland to Central African Republic". However, the latter country (CAR) is also far outside the drawn range so that the small map sketches by Branch (2008) are not reliable. Apart from a record from the Burkina Faso part of RBTW (Chirio 2009), *P. castaneus* is also registered in the grid map by Trape et al. (2012) in the southwest of Burkina Faso, i.e., in the area of our voucher specimen.

*Agama agama* (Linnaeus, 1758)

**Mali:** ZFMK 91052, male, Douentza, J. Heath, VII.2010;

**Burkina Faso:** ZFMK 93950–955, 2 males, 1 female, 3 subadults, 4 km NE Dérégoué, near gallery forest of the Koba River; ZFMK 93970, Ouagadougou.

The taxonomy of this widespread and anthropophilous lizard is complicated, since it represents a species complex of closely related forms. Moreover, its Linnean type series, composed of three different species, has been differently interpreted by Wagner et al. (2009) and by Mediannikov et al. (2012). In the light of the results by Leaché et al. (2014) we follow the concept of the former authors.



**Fig. 8.** *Agama sankaranica* from NE of Dérégoué (left) and from Ouagadougou (right), Burkina Faso. Note the absence of a light vertebral line in the right specimen.

*Agama sankaranica* Chabanaud, 1918

**Burkina Faso:** ZFMK 93956, 4 km NE of Dérégoué, near gallery forest at the Koba river.

A former voucher specimen from Burkina Faso (ZFMK 39032) was the first country record of this species (Böhme et al. 1996). The two voucher specimens (Fig. 8) differ in that one (ZFMK 93956) has a white middorsal line as described to be typical for this species (Trape et al. 2012), the other belongs to the less common morphotype without such a stripe. The specimens bridge a distributional gap between two records in Mali and one each in NE Ivory Coast and NW Ghana. From Burkina Faso, there is only one earlier record on the map by Trape et al. (2012) in the centre of the country. It may be noted that the easternmost records of *A. sankaranica* in this map are situated in central Nigeria (Jos Plateau), ignoring a record from Minim, Adamaoua Plateau, Cameroon (Böhme & Schneider 1987) which extends the distribution range of this species for more than 500 km further towards the





**Fig. 9.** *Agama* sp. from Dérégoué, Burkina Faso. Left: male, and right: female.

southeast. Recorded also for the Burkina Faso part of the RBTW in the east of the country (Chirio 2009).

#### *Agama* sp.

**Burkina Faso:** ZFMK 93948–949, male and female, 4 km NE of Dérégoué, near gallery forest at the Koba River.

The two specimens (Fig. 9) seem to be interesting because they are small and nonetheless seemingly adult, having a head-body length of only 69 and 65 mm respectively. They are not yet assignable to a described species. Since they also belong to the *A. agama* species complex, their identity can only be cleared by extensive interspecific comparisons for which the present faunistic study is not the right place.

#### *Chamaeleo gracilis* Hallowell, 1842

**Burkina Faso:** ZFMK 101235, 4 km NE Dérégoué, gallery forest at the Koba River.

Although stated to be widely distributed in Africa, from Senegal to Ethiopia and Tanzania (Trape et al. 2012), there is no locality record for this chameleon in Burkina Faso on the grid map of these authors, although it was recorded from Burkina Fasoan part of the RBTW in the easternmost part of the country and only one in southern Mali. From *C. senegalensis* which is known from several localities in both countries, our *C. gracilis* female is distinguished by the shape of the casque and the rudimentary occipital flaps which are virtually absent in the former species. It seems that our specimen is the second documented voucher specimen from Burkina Faso, next to a record given by Chirio (2009) for the easternmost edge of the country, just at the border to Benin which is not included in the map by Trape et al. (2012). It documents thus a much wider potential distribution in this country than assumed before.

#### *Chalcides ocellatus* (Forskål, 1775)

**Mali:** ZFMK 90467, 91055–056) from Anda village between Douentza and Bandiagara.

The three voucher specimens of this widely distributed species are the second record of this species from Mali. Before, this skink was only once reported from Mali by Greenbaum et al. (2006) from two localities, viz. Tombouctou and between Kona and Sévaré (Joger & Lambert 1997, see also Trape et al. 2012).

#### *Chalcides delislei* (Lataste & Rochebrune, 1876)

**Mali:** ZFMK 93764, Pergué, sand dunes outside the village.

A Saharan element with several records in south-central Mali where also our voucher specimen comes from.

#### *Leptotyphlops albiventer* Hallermann & Rödel, 1995

**Burkina Faso:** ZFMK 97767, 4 km NE Dérégoué, near gallery forest at the Koba River.

This species was described from the Comoé National Park in northern Ivory Coast (Hallermann & Rödel 1995) and subsequently recorded from Guinea Bissau and Mali (Trape & Mané 2006, 2017). In Trape & Mané (2017) the authors used the new generic name *Myriopholis* Hedges, Adalsteinsson & Branch, 2009, created in the course of a family-wide new molecular phylogeny by Adalsteinsson et al. (2009). *Myriopholis albiventer* was, however, placed in this genus without molecular data, and a micro-CT scan of ZFMK 97767 showed that its skull characters do not fit the pattern of the other *Myriopholis* species but rather resemble the situation in *Leptotyphlops* in the strict sense (Claudia Koch, unpubl. data), so that we maintain here its original genus name. Our specimen has a total length of 120 mm, which is near the maximum for this species, and the relations of its total length to tail





**Fig. 10.** *Leptotyphlops albiventer* from Dérégoué, Burkina Faso.

length as well as to its body diameter, the midbody scale count, the number of subcaudals and the color pattern of a brownish dorsal and a whitish ventral side fit the characteristics of this species as described by Hallermann & Rödel (1995) and Trape & Mané (2006). ZFMK 97767 (Fig. 10) documents thus the fourth record from a fourth country, but the first for Burkina Faso.

***Lamprophis fuliginosus* (Boie, 1827)**

**Burkina Faso:** ZFMK 93971, Bobo Dioulasso.

A widespread, partly anthropophilous snake (vernacular name “house snake”) distributed in sub-Saharan West Africa from the forest belt up to the Sahelian savanna (Trape & Mané 2006).

***Lamprophis lineatus* (Duméril, Bibron & Duméril, 1854)**

**Burkina Faso:** ZFMK 101291, Bobo Dioulasso.

This close relative of the former species is known to be broadly sympatric in West Africa including Burkina Faso (Trape & Mané 2006).

***Naja nigricollis* Reinhardt, 1843**

**Burkina Faso:** ZFMK 101547, Dérégoué (a mutilated adult specimen).

Widely distributed in the sahelian, sudanian and guinean savanna types of West and Central Africa. In both Mali and Burkina Faso *N. nigricollis* is represented in most parts of these countries (see the map in Trape & Mané 2006). According to these authors, West African specimens are entirely black above and below, except some light ventral crossbands below the neck and the anterior part of the body. ZFMK 101547 corresponds to this characterization.

***Bitis arietans* (Merrem, 1820)**

**Burkina Faso:** ZFMK 101290, 10 km SE Tiéfara.

As the former species widely distributed in West Africa including Burkina Faso (Trape & Mané 2006).

***Echis leucogaster* Roman, 1972**

**Mali:** ZFMK 91055 (head and forepart only) 91056 (mutilated subadult), Douentza.

This Sahelian species is common and widely distributed both in Mali and in Burkina Faso. Our two specimens are badly damaged and thus not suitable for providing scale counts which would be necessary to corroborate their identification against the sympatric congeners *E. jogeri* and *E. ocellatus* (Trape & Mané 2006, 2017). However, head and neck size of ZFMK 91055 and the unspotted white underside in both specimens argue for *E. leucogaster*, as does the locality Douentza which is situated in a center of Malian records (Trape & Mané 2006).

**APPENDIX: PHOTOGRAPHIC VOUCHERS**

Some locality records which are based on photographs only have been separated from the species list above since the physical specimens are absent. However, in all cases except *Tarentola* cf. *ephippiata*, their specific identification is indubitable.

***Hemisus marmoratus* (Peters, 1854)**

**Burkina Faso:** Photo voucher (Fig. 11), Karankasso-Vigué, pasture ground with swamps.

The first record of this burrowing frog in Burkina Faso was made by M.-O. Rödel in 1992 (Böhme et al. 1996) from halfway between Ouagadougou and Bobo Dioulasso. This photographic record extends the range southwards towards Ivory Coast where Rödel (2000) recorded it from the Comoé National Park. It has not yet been listed for Mali so far.

***Ptychadena schubotzi* (Sternfeld, 1917)**

**Burkina Faso:** Photo voucher from Karankasso-Vigué.

*Ptychadena schubotzi* is the savanna sibling of the forest-dwelling *P. longirostris* with which it has often been mixed up in the past (Perret 1981, Rödel 2000). It is widely distributed over the sub-Saharan savanna belt countries and was first discovered in Mali by Schätti (1986) and in Burkina Faso by Böhme et al. (1996).

***Amnirana galamensis* (Duméril & Bibron, 1841)**

**Burkina Faso:** Photo voucher, Karankasso-Vigué.

Not to be mistaken and thus a reliable locality record.





**Fig. 11.** *Hemisus marmoratus* from Karankasso-Vigué, Burkina Faso.

*Tarentola cf. ehippiata* O'Shaugnessy, 1857

**Mali:** Photo voucher from Douentza.

*Tarentola ehippiata* turned out to be a species complex, and some forms described as subspecies have been lifted to specific rank (Trape et al. 2012). According to these authors, the Bandiagara-Douentza area has two forms of this complex (*T. ehippiata* sensu stricto and *T. hoggarensis*) occurring in sympatry, thus corroborating their specific status. The identification of these two close relatives after a photograph only is difficult, so the above assignment remains tentative.

*Tropicolotes tripolitanus* Peters, 1880

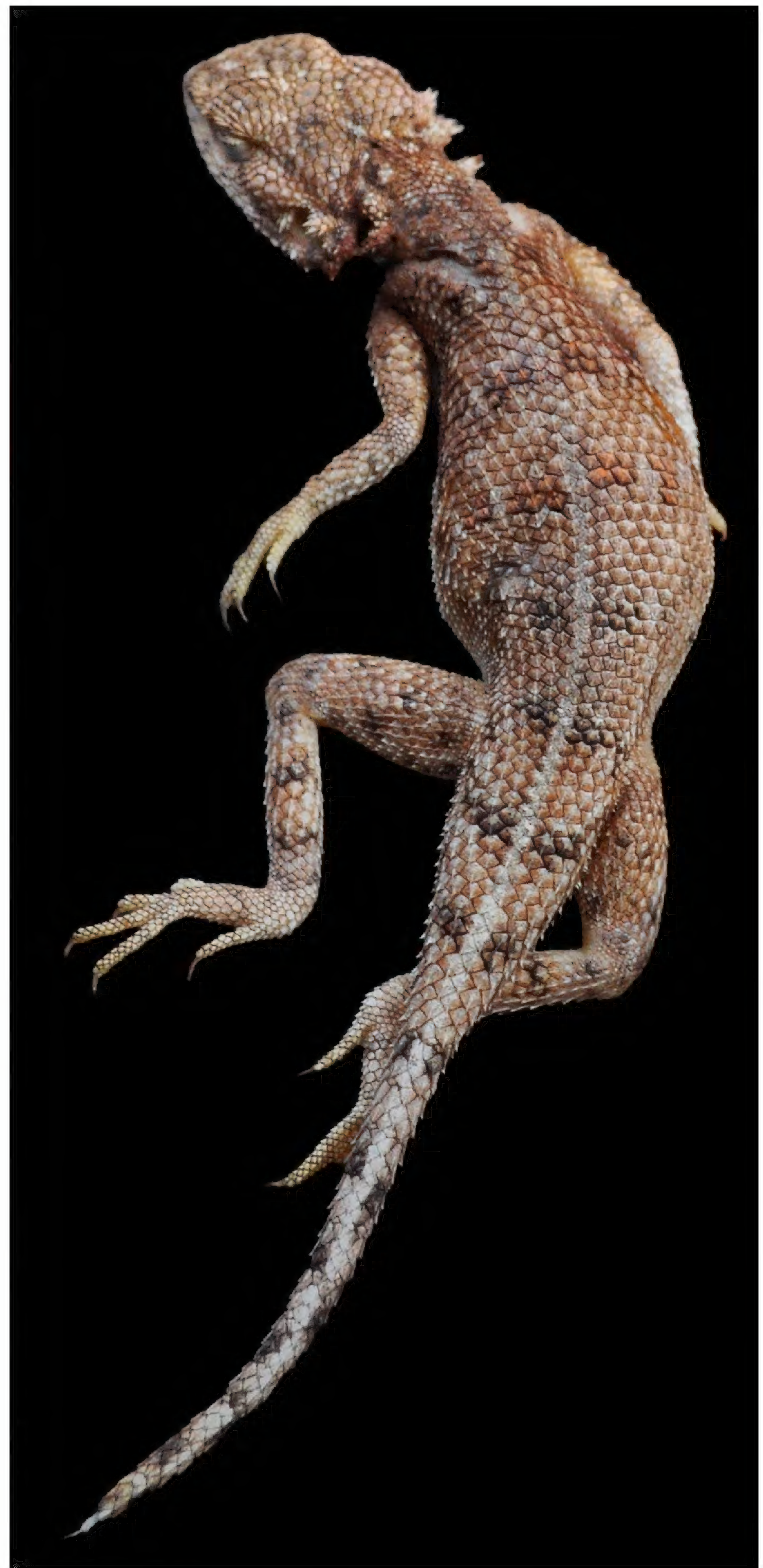
**Mali:** Photo voucher from Kikara near Douentza, near mountain top, under stones.

This Saharan faunal element has a disjunct distribution on the southwestern and northeastern margins of the Sahara. In the southwestern part of its range, it is distributed in Mauritania and Mali (Trape et al. 2012). The identification of the photographed specimen as *T. tripolitanus* is unproblematic since only two well distinguishable species are possible to occur in the area.

*Agama boueti* Chabanaud, 1917

**Mali:** Photo vouchers from Douentza, Tupéré near Boni, and Koporo Pén.

This ground-dwelling *Agama* was described after two specimens from Gao on the Niger River in Mali and considered to be so rare that even its validity was questioned (Wermuth 1967). But six decades later it was found to be very common close to Dakar, Senegal (Böhme 1979), and subsequently also recorded from the Air Mountains, Republic of Niger (Joger 1981). Today it is known to be continuously distributed in the Sahelian belt from Senegal to Niger (Mediannikov et al. 2012, Trape et al. 2012),



**Fig. 12.** *Agama boueti* from Douentza, Mali.

and our records from the Douentza area (Fig. 12) in Mali fit well into this pattern.

*Latastia longicaudata* (Reuss, 1834)

**Mali:** Photo voucher, Douentza.

This long-tailed lacertid lizard has a wide sub-Saharan distribution across the Sahelian savanna belt. For West Africa, the grid map in Trape et al. (2012) shows a concentration of records in western Senegal and northern Cameroon, connected by scattered grid cells in Mali,





**Fig. 13.** *Latastia longicaudata* from Douentza, Mali.

Niger and northern Nigeria. For Mali, there are only two grid cells given (Trape et al. 2012) which evidently refer to Goundam and south of Gao (see Joger and Lambert 1996) and their distance from each other is bridged by our record (Fig. 13) from Douentza.

**Acknowledgements.** We thank Mark-Oliver Rödel and Michael Barej, (Museum für Naturkunde Berlin: ZMB), for commenting on frog specimens, Claudia Koch (ZFMK), for sharing unpublished information on leptotyphlopoid osteology, and Morris Flecks (ZFMK) for valuable help with the figures. One of us (JH) wants to thank Seydou Moro from Anda/Douentza, and Omar Pergourou from Pergué/Douentza for their hard work to collect some voucher specimens. We are also grateful for constructive reviewer's comments.

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